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A SAWDUST-COMPRESSING MACHINE.

By Charlton Lawrence Edholm.

A machine that compresses ordinary sawdust into fuel for domestic purposes has been invented by a resident of Los Angeles, and the product is now being marketed in that city.

This fuel comes in a very convenient form, 3 x 12-inch cylinders. These are so hard that a hammer cannot dent them, and they are clean and dry, for the particles of sawdust are not held together by any sticky foreign substance, but simply by compression.

The machine, shown in the accompanying photograph, is equipped with two plungers, which force the sawdust through a steel die with a pressure of thirty tons. Through the center of the cylindrical die, which has a diameter of three inches, runs a rough, loosely twisted hempen cord, and this forms a core about which the sawdust is compressed, and which serves to keep it from flaking. This cord is fed into the machine automatically, and as the hard mass of sawdust is forced from the machine a knife, operating by a trigger, cuts it into the desired lengths.

In burning, the sawdust sticks are sootless, and make very little smoke and ashes. There is a brisk demand for this new fuel, and a good price can be obtained for a product of waste matter. This machine has a capacity of five tons a day, and operates by electricity.

GREAT MASONRY ARCHES.

Many stone arches of great size and bold construction were built in the Roman and medieval periods. Modern engineers employ steel for very long spans, but the construction of stone arch bridges of great dimensions is not yet obsolete. Among the most notable bridges are the following:

The bridge of Alcantara, in Spain, is composed of six arches, two of which have spans of nearly 100 feet. The roadway of the bridge is nearly 200 feet above the bed of the stream which it crosses. This bridge was built in the year 98 A. D., in the reign of the Roman Emperor Trajan.

The bridge of Trezzo, in Lombardy, crosses the river Adda by a single circular arch of 237 feet span and 68 feet rise. The radius of the intrados is 137.5 feet and the arch has a uniform thickness of 7.4 feet. Its width is also uniform from base to crown. This bridge was built in 1370-1377 by the Duke of Milan, and destroyed, after the capture of the castle of Trezzo, by the Count of Carmagnola in 1416.

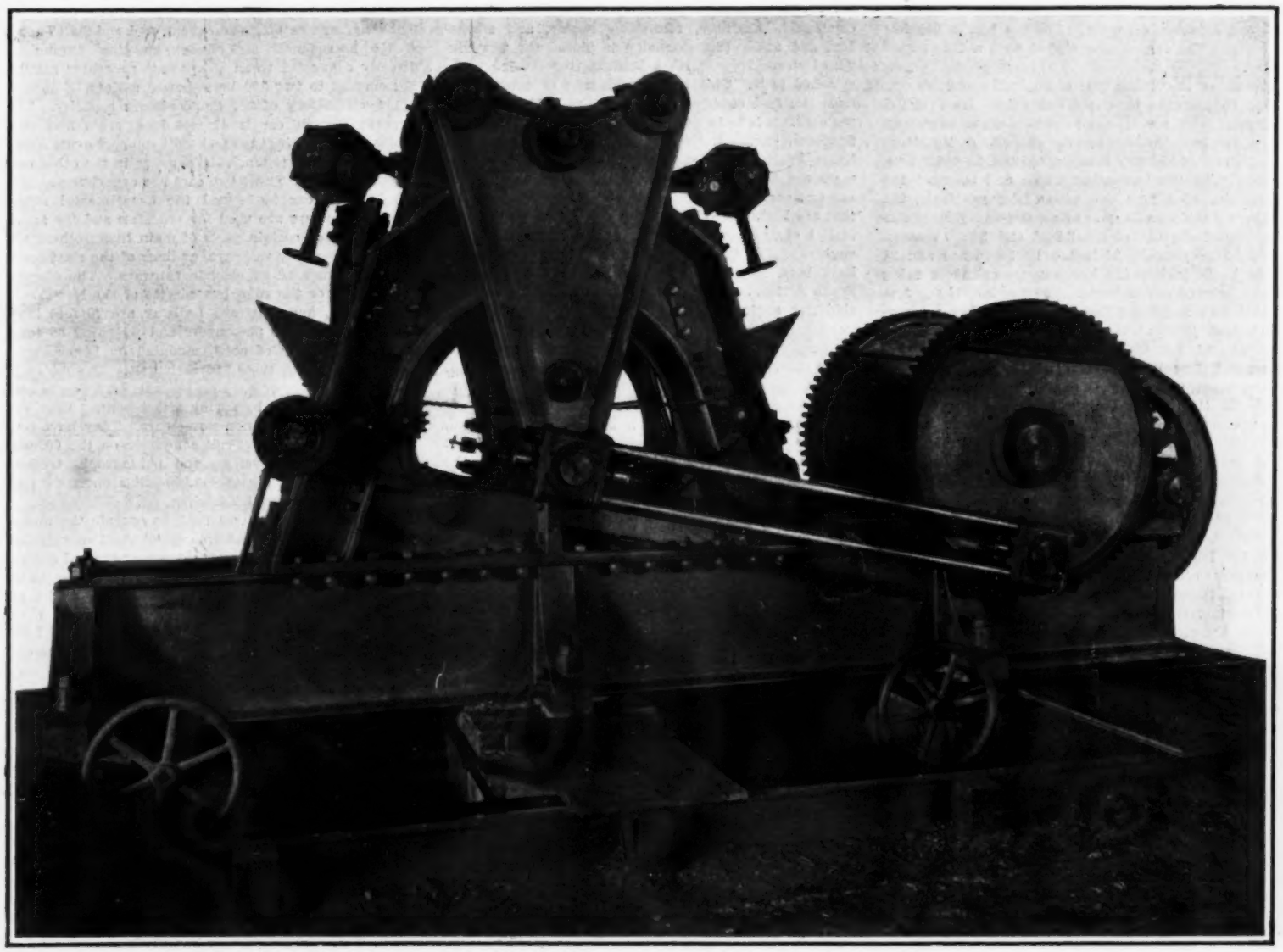
The aqueduct which supplies the city of Washington passes, at Cabin John, over an arch of 220 feet span and 57 feet rise, with a thickness of 20 feet at the base and 9.5 feet at the crown. This bridge was constructed in 1860-1862.

The railway bridge at Liavaux, France, crosses the river Agont by a single circular arch of 202 feet span and 90 feet rise. The arch is 5.4 feet deep at the crown. This arch, which was constructed in 1882-1884, was the largest in France before the completion of the arch over the Valserine, at Moulin des Pierres, in November, 1909.

The single arch of the railway bridge at Montbegnon, near the lake of Como, in Italy, has a span of 230 feet, but little elevation. The central arch of the Luxemburg bridge, which was completed in 1902, has a span of 278 feet at its foundation and a span of 236 feet at the level, 53 feet below the bottom of the keystone, at which it separates from the adjacent arches.

The railway viaduct at Salcano, Austria, contains an arch of 279 feet span and 78 feet rise, with a thickness of 11.5 feet at the base and 6.6 feet at the crown. The total height of the structure above the valley is 105 feet. It was completed in 1906.

The largest masonry arch in existence is at Planen, in Saxony. It has a span of 295 feet, a rise of 59 feet and a thickness of 13 feet at the base and 4.9 feet at the crown. The radius of curvature of the intrados at the keystone is 344 feet.



A SAWDUST-COMPRESSING MACHINE OPERATED BY ELECTRICITY.

Red wax varnish is useful for painting parts of woodwork, wires of galvanometers and magnets. Small pellets of sealing-wax are shaken up with warm methylated spirits and dissolved. The viscid liquid is applied with a small camel's hair brush in two or more coats, according to the thickness required.

RECENT AMERICAN LOCOMOTIVES.*

AN ENGLISH VIEWPOINT.

Two interesting American locomotives of special design built in 1909 are three-cylinder and four-cylinder simple engines, both of the 4-4-2 class for passenger service. The three-cylinder engine of the Philadelphia and Reading Railway has cylinders 18½ inches by 24 inches, and driving wheels 6 feet 8 inches diameter. The Walschaerts valve gear is used for the outside cylinders, and the Joy valve gear for the inside cylinder. The fire box is 6 feet by 9 feet. This engine weighs 103 tons, with 56 tons on the driving wheels. The four-cylinder simple balanced engine of the Chicago, Rock Island and Pacific Railway has four cylinders 17½ inches by 26 inches all connected to the first driving axle. The steam distribution on each side is effected by two piston valves on a single valve stem, so that there is no complication in valve gears, each side of the engine having a single Walschaerts gear. Superheated steam is used. The driving wheels are 6 feet in diameter, and the engine weighs 100 tons, with 58 tons on the drivers. The cylinders are placed far enough ahead of the first driving axle to allow of a connecting rod 7 feet long, and this necessitates an increase of 2 feet in the length of the boiler, which is 5 feet 8 inches diameter. The fire box is 8½ feet by 5 feet. The engine is equipped with a Cole superheater.

The use of the Mallet type of duplex locomotive continues to increase to a marked extent, and Mallet engines of some special and unusual designs have been put in service. To increase the capacity of its mountain division, with very heavy gradients, in order both to cope with the increasing traffic and to meet the competition of a new line with easier gradients, the Southern Pacific Railway is using some very large sixteen-coupled engines of the 2-8-8-2 and 2-8-8-0 classes. These have cylinders 26 inches by 30 inches and 34 inches by 30 inches, the low-pressure cylinders being on the forward steam bogie. The fire box is 6½ feet by 10½ feet, and the 7 feet boiler barrel has a separable bolted joint at the combustion chamber. The tubes are 21 feet long, terminating in a combustion chamber 5 feet long, beyond which is a feed-water heater, which is a duplicate of the boiler barrel, 5 feet long. In the smoke box is a superheater for the low-pressure cylinders only. A hand valve admits live steam to the low-pressure cylinders in starting by means of a pipe so small that no reducing valve is required. The Walschaerts valve gear is used, and the reversing gear is operated by compressed air. The frames of some of these engines are of vanadium cast steel. The engines weigh about 212 tons, with 197 tons on the driving wheels. Many of the engines use oil fuel, and as these work a line having numerous tunnels and snowsheds the engines run with fire box in front, the cab arrangement being similar to that used on some of the Italian locomotives. With these very long engines the smoke and gases striking the roof of the tunnel were deflected downward so as to envelop the cab. In order to prevent this action some railways are using a movable hood on the funnel; this is thrown up when the engine enters a tunnel, so that the steam and smoke are ejected backward horizontally, instead of vertically upward. The tenders of the oil-burning Mallet engines carry 9,000 gallons of water and 2,850 gallons of oil. They weigh 85 tons loaded.

The Atchison, Topeka, and Santa Fé Railway has made a decided innovation in the use of Mallet engines for heavy passenger trains, the engines having a tractive effort of 53,000 pounds. These engines have a peculiar wheel arrangement: 4-4-6-2. That is, a four-wheel leading bogie carries the front end of the steam bogie, which has four driving wheels. Behind this is a group of six driving wheels in the main frames, with a two-wheeled trailing bogie under the fire box. The boiler is very similar to that of the Southern Pacific engine above described, but has a superheater for high-pressure steam and a reheater for low-pressure—exhaust—steam, both placed in a combustion chamber, 10 feet long. Beyond this is the tubular feed-water heater, 7 feet long, and then the smoke box, 5 feet long. The boiler barrel proper has tubes 19 feet long, and the fire box is of the Jacob-Shupert type, described recently in The Engineer. The inside and outside shells are composed of a row of steel channels, bent to horseshoe shape, and riveted together at the flanges. The grate is 10 feet by 5¼ feet. The usual outside steam pipes from the dome are dispensed with, the pipes connecting with the superheater, and coming out near the bottom of the shell. The cylinders are 24 inches by 28 inches and 38 inches by 28 inches; and the driving wheels 6¼ feet diameter. The total wheel-base is 52 feet—94 feet with tender—and the total weight is 188 tons, with 144 tons on the driving wheels. This railway is using also a number of Mallet goods engines of the 2-8-8-2 class, with boiler construction as in the other engines. The tractive effort is 108,000 pounds. These engines have cylinders 26 inches by 34 inches, and 38 inches by 34 inches, with driving wheels 5¼ feet diameter. The total weight is 230 tons, with 206 tons on the sixteen driving wheels. The boiler—with tubes 21 feet long—has 5,004 square feet of heating surface, 544 square feet of superheater surface, 1,201 square feet of reheating surface for the high-pressure exhaust, and 1,617 square feet of feed-water heating surface. The grate area is 71 square feet. The tender weighs 112 tons; it carries 4,000 gallons of oil and 12,000 gallons of water. The Mallet engines of another railway are proving so satisfactory, that a number of older goods engines of the 2-8-0 class are being converted to the Mallet type, with 2-6-6-0 wheel arrangement. The leading bogie and first driving axle are removed, the original cylinders 20 inches by 32 inches, remaining as high-pressure cylinders to drive the three remaining axles. The smoke box is removed, and replaced by a shell containing the combustion chamber, feed-water heater, and smoke-box, and under this extension is placed the new six-wheel steam bogie, with a leading two-wheeled bogie attached to it. This reconstruction is expected to reduce the fuel consumption per ton-mile by nearly 50 per cent. It is to be noted that the huge engines of the Southern Pacific Railway, and Atchison, Topeka, and Santa Fé Railway, noted above, are not experimental machines by any means, but that large numbers of the engines are in regular service, and giving results that are highly satisfactory. Other railways are using Mallet engines of smaller sizes, and large and small engines of this type—including narrow gage engines—have been built for export to Natal, Brazil, Central South Africa, and the U. S. of Colombia. The last is a side-tank engine.

With regard to locomotive machinery, mention may be made of the increasing use of the Baker-Pilliod valve gear. This has no sliding links or blocks, but all parts have positive pin connections, and there are three fixed points in the gear. For engines of all classes the Walschaerts gear is being extensively used, and it is used almost exclusively in the huge Mallet engines. Something new in boiler construction is the Jacob-Shupert fire box, already noted, and the Jacob's superheater has been applied to a number of boilers. This latter consists of two drums with horizontal tubes, placed in the smoke box, one forward of and the other behind the blast pipe. Boiler steam is delivered to the front drum, is diverted around the tubes by baffle plates, and then passes to the second drum, from which it passes to the cylinders. For tandem-compounds and Mallet engines the steam goes direct from the first superheater drum to the high-pressure cylinders; the exhaust is led to the second drum—or reheater—and then goes to the low-pressure cylinders. The products of combustion pass through the tubes and around the drums to the front of the smoke box, and return through a flue in the forward drum to a draught pipe leading up to the funnel.

There is an increasing use of feed-water heaters. The great length of boiler practicable for the Mallet engines makes it easy to use a tubular heater in the manner described. For ordinary locomotives heater drums are placed on or beside the boiler, and are heated by waste steam from the brake pump or a part of the exhaust steam. In some designs also, a pipe coil in the smoke box utilizes some of the waste heat from the products of combustion. One railway, however, diverts a part of the waste steam into an auxiliary tank in the tender, this being fed automatically from the main tank. The exhaust from the brake pump being generally diverted into the funnel sometimes increases the draught when least required, causing unnecessary fuel consumption. To avoid this one railway has applied auxiliary waste or exhaust pipes, so that the brake pump may exhaust into the open air or into the funnel as may be desired.

In addition to the use of oil-burning locomotives in districts where oil is plentiful, their use has been made compulsory on all railways traversing the Adirondack forest region in New York State. This step has been taken on account of the numerous disastrous forest fires due directly to coal-burning locomotives, in spite of special spark arresters and other precautions. The compulsory use applies only to the summer and autumn.

A new rotary snow plough has been built, which has in front two horizontal drums, end to end, with axes transverse to the rails. On these are spiral blades which throw the snow upward and outward to each side of the railway. The drums are driven by gearing from a 750 horse-power engine running at 200 revolutions, and the velocity of the periphery of the spiral blades is 5,630 feet per minute. The machine is mounted on bogies and weighs 60 tons.

Electric and compressed air locomotives and small tank engines are common enough for mines, works railways, industrial plants, and contractors' work; but some firms in America are now introducing small gasoline locomotives for this class of work. In railway motor cars the type in most general use is the McKeen gasoline car with direct chain drive from the six-cylinder engine to one axle of the front bogie which carries the engine. There are about sixty of these now in use. They are of various sizes, the largest being a 70-foot car weighing 33 tons. The cars are peculiar in appearance, with pointed front end, semi-circular rear end, a door in the middle of each side, and large circular windows. To the rear of the entrance is the main passenger compartment. Forward are the smoking compartment, luggage and mail compartment, and engine-room. Two types of gasoline electric cars have been built. The Strang car is 62 feet long, carries fifty passengers, and weighs 57 tons. A 150 horse-power six-cylinder gasoline engine is directly connected to an 85-kilowatt generator supplying current to two 100 horse-power motors. There is a 112-cell battery of 300 ampére-hours capacity. The General Electric car is 45 feet long, seats fifty passengers, and has luggage and mail compartments. The power equipment is much the same as in the other car, except in detail. These two cars are experimental, but the McKeen car is beyond the experimental stage. Some of the cars are used for branches and for auxiliary service on certain parts of main lines; others are used for secondary railways, or lines of the class more generally operated as electric railways. The electric motor cars for the suburban service of the New York, New Haven, and Hartford Railway are 70 feet long, seating seventy-two passengers and weighing 85 tons. They are entirely of steel, mounted on bogies, with a 200 horse-power motor to each axle. The motor is geared to a sleeve or quill on the axle, and this is connected to the wheel by spring attachments. Each car can haul two similar non-motor cars. They have contact shoes for the third-rail conductor on the 600-volt continuous-current system, and pantagraph trolleys with bow contacts for the 11,000-volt alternating current system with overhead wires.

The electric locomotives built to operate the underground terminal line and tunnels of the Pennsylvania Railway at New York represent a new type of design. Each complete unit resembles two four-coupled bogie engines, coupled back to back, making a 4-4-4-4 arrangement. The tractive effort is 60,000 pounds. Upon the main four of each half unit is a Westinghouse 2,000 horse-power motor, taking 600-volt continuous current. Crank arms on the motor shaft are connected by rods to the crank arms on a jack shaft behind the bogie, and from this extend ordinary connecting-rods to the fast driving wheels. Thus the center of gravity is unusually high, about 6½ feet above the rails. The driving wheels are 5¾ feet diameter, and the total weight of the complete unit is 166 tons, of which 104 tons are carried by the driving wheels. The requirements are severe, the engine being capable of starting 550 tons of train load on a gradient of 1 in 50 in the tunnels, and hauling the train at 30 to 60 miles an hour on the open line. In June, 1909, the Great Northern Railway began operating its Cascade Tunnel by electric locomotives. The tunnel is 13,875 feet long, with a gradient of 1 in 60. Steam service was by two Mallet engines to a train, one at each end, but the operation was dangerous on account of the smoke and gases, and the heat. After each train, 20 to 60 minutes had to be allowed for the tunnel to become clear. A hydro-electric plant has been built 30 miles distant, of 5,000 kilowatts capacity, generating 6,600-volt, 25-cycle current. It is transmitted at 33,000 volts to a sub-station, where it is reduced to 6,000 volts for the trolley line, and then converted by three-phase transformers on the engine to 500-volt continuous current for the four motors. The engines are of the 0-4-4-0 type, with articulated bogies having 5 feet wheels. The gear ratio is 4.26, and the tractive effort 80,000 pounds. The steam locomotives are hauled through with their trains, but eventually the electric locomotives will operate the entire division of 60 miles in length, having gradients from 1 in 60 to 1 in 46.

The electric locomotives for the new Detroit subaqueous tunnel are also of the 0-4-4-0 type; the two fan-wheeled driving bogies are hinged together or articulated, so that they take all the draught and buffing stresses direct. They are of 1,200 horse-power,

* The Engineer.

weigh 100 tons, and have four continuous-current motors which have forced ventilation. They are 40 feet long, and have a tractive effort of 36,000, with a maximum speed of 35 miles an hour. The gear ratio is 4.37. The engine is capable of hauling an 1,800-ton train of wagons at 10 miles an hour on the 1 in 50 approach gradients. The new electric goods locomotives for the New York, New Haven, and Hartford Railway are of the 2-4-4-2 class, with a two-wheeled bogie carried at the end of each four-wheeled driving bogie. On each axle is a 300 horse-power single-phase motor, with auxiliary apparatus for operation from the 600-volt continuous-current conductor rail on one part of the line, and the 11,000-volt alternating current trolley wire on the remainder of the line. The engine is 50 feet long, and weighs 130 tons, with 95 tons on the 5¼-foot driving wheels. It can haul a 1,500-ton train at 35 miles, or an 800-ton train at 45 miles an hour. An experimental engine of the 4-6-2 class has two 800 horse-power single-phase alternating current motors mounted above the frame, with cranks and connecting rods to two end countershafts, from which return rods lead to the wheels. Still another electric locomotive, built for experiment, has a friction-wheel connection to the wheels instead of the usual gears to the axles. A 75 horse-power motor mounted between the axles of the driving bogie, carries at each end a 12-inch wheel engaging with the treads of one pair of wheels. The motor runs continuously, and is raised and lowered by a pneumatic apparatus so as to put the wheels in or out of action. Tests of this machine in competition with an ordinary geared locomotive having two motors of 35 horse-power showed a considerable saving in current.

Heavy trains are a prominent feature of American railway service, especially where there is a constant and heavy traffic of iron ore or coal. On the Virginian Railway, built with easy gradients and equipped with powerful locomotives for heavy coal traffic, a train of no less weight than 9,120 tons has been hauled by a Mallet engine. This was for 120 steel wagons, each carrying 55 tons of coal and weighing 76 tons loaded. The engine weighs 160 tons; tender, 80 tons; gross total 9,360 tons. The standard coal train on this road consists of 80 wagons, with 4,400 tons of coal; the weight—including wagons—is 6,132 tons; to this must be added 18 tons for the brake van, 135 tons for the engine, and 80 tons for the tender, or a gross total of 6,355 tons. The regular locomotives of these trains are of the 2-8-2 class, weighing 135 tons, with 110 tons on the 4¾ feet drivers. The cylinders are 24 inches by 30 inches, and the boiler has 4,530 square feet of heating surface, with 51 square feet of grate.

Trains in excess of the standard have been hauled in many cases up to 7,800 tons, and the run of 125 miles to the shipping port is made at the rate of 15 miles per hour, including the time for all stops. On the Pennsylvania Railway a train of 105 steel wagons with 5,540 tons of coal, and a gross weight —including engine—of 7,644 tons, made a run of 127 miles in seven hours. Coal trains of 4,850 to 6,150 tons gross total weight have also been hauled on this railway. On the Lake Shore and Michigan Southern Railway a train of 100 steel wagons carrying iron ore and weighing 7,430 tons was hauled 65 miles at an average speed of 12 miles an hour. In some cases these very heavy trains are due to special conditions, such as a previous congestion of traffic at some point, but it is worth noting that the standard coal train of the Virginian Railway has a gross total weight of 6,365 tons and a net load of 4,400 tons of coal.

SOME PRINCIPLES OF EFFICIENCY.

CURING A SICK INDUSTRY.

BY HARRINGTON EMERSON.

THE owners of a large industrial plant with many orders ahead desired to increase the output from thirteen units a month, the highest average up to that time, to twenty-three units a month, and to do this in ten months.

The manager of the plant, a man of unusual ability but of the old school, had been in charge for some time, but knew only one way to deliver the increase, namely, to add to the equipment and employ more men. He therefore countered the demand of the owners for twenty-three units by asking for $500,000 worth of additional equipment. Even if this capital investment had been possible, it was no solution of the difficulty, as it would have taken at least a year, probably longer, to secure the new equipment.

When matters were in this state—demand for increased output by owners, demand for increased equipment by manager—an investigation of the plant was made by two competent efficiency engineers of wide experience, who submitted a long report of which the concluding paragraphs were:

Your plant consists of a large machine shop, boiler shop, erecting shop, blacksmith shop, foundry.

Having examined into the conditions of each of the shops and having consulted with the manager, the superintendent, the various foremen, some of the contractors, and a number of men, we are able to state definitely that with some slight physical betterments, and provided the present manager or a man of similar disposition be in authority, the output of your shops can be increased 60 per cent, without adding to the present forces, without adding to the equipment, and without increasing the payroll more than 10 per cent, and that these results can be gradually attained within a period of six months.

To accomplish these results certain principles of organization were advocated. The organization and principles were adopted and applied by the manager, and the results are shown by an extract from a letter, written by the local official ten months later.

New York, May 1, 1908.

It will interest you to know that our output for the month of April showed an increase of 69.2 per cent over the monthly average of the last fiscal year.

The average working hours are 9 per day instead of 10 as formerly. The payroll reduction is 15 per cent, amounting to $8,000 to $10,000 a month less than last year.

The same efficiency engineers were subsequently called to another plant, to investigate and to advise. In this case also their principles were accepted, their recommendations carried into effect through modified organization with the following results:

Date.	Average Number of Men.	Average Tons per Man.	Total Tonnage.	Pay Roll.	Pay Roll Cost per Ton.	Increased Earnings of Men, Per Cent.
September, 1908	527	4.69	2,473	$29,380	$11.88	0.0
July, 1909	263	9.04	2,377	15,248	6.41	2.0
August, 1909.....	298	10.51	3,133	17,380	5.51	10.0
September, 1909.....	312	10.92	3,408	17,394	5.14	17.3

It is not to be supposed that two men could come from the far West, go into Eastern industrial plants, and through their own familiarity with the conditions know better how to direct them than the experienced local managers in charge. The men who came out of the West were not as well equipped with knowledge of operation or devices, were not as well acquainted with local methods and men, as the local managers, but they were far better equipped with knowledge of a new type of organization through which alone efficiency can be secured, and they had not only this knowledge, but also extended and successful experience in applying it. The difference in achievement between the modern man and the men who lived thousands of years ago is not an internal difference in quality of brain, but the tremendous external difference in conditions and equipment. The boy with the far-reaching sling knocks out the heavily armored spear-wielding giant.

It is exceedingly difficult to advocate certain principles without individuals, tribes, and nations, unable to free themselves from the personal point of view, immediately jumping to the conclusion that an attack is being made on their competency, their skill. Greek athletes could have made good records if they had had bicycles, motor cars, and aeroplanes, if they had had repeating pistols and rifles; but the arrow, however skilled the archer, does not carry as far or as straight as the rifle bullet. The principle underlying the rifle is very old—that of the blow tube—a very different principle from that of the bow and string; but the man who equips the savage with a rifle makes him more powerful than all the armored knights of chivalry, and the man who equips the modern industrial manager with a new industrial application of an old principle of organization and accomplishment, gives the mediocre manager a greater possibility of attaining high efficiency than was ever possessed even by the greatest industrial geniuses working along the old lines.

The men from the West knew the new theories because they had applied them on a tremendous scale; they knew how to design and operate a new kind of shop control, as different from the old as the rifle is from the bow—as different as bicycle riding is from walking, flying from motoring, Arabic notation from Roman numerals. These principles in their application to shop control may not appear particularly lofty, inspiring, or even interesting to anyone except those whose pocketbooks are to be immediately benefited—namely, the plant owners and managers, the plant workers, and the clients of the plant; but they will evoke deeper interest when it is perceived that they are fundamental and of universal application; that in all ages lasting efficiency depended on them, and without them is always impossible; that the same principles have been applied elsewhere on a stupendous and noble scale, and that it is not men or materials, money, machines, and methods that count, but far more potently, theories and principles.—Engineering Magazine.

The Pennsylvania Railway is now using signal instruction cars on all divisions. The new cars in use on the main line are 60 feet long, divided into two compartments. One room will be used for examinations, while the other will contain a table upon which is to be placed under a glass cover a large track chart of the railway, which can be rolled back and forth by means of rollers placed at each end. This chart shows all main running tracks, switches and cross-overs, all signals, track troughs, stations and mile posts. The men will be given an opportunity to study this chart prior to passing an examination on it. Each car is provided with a set of model signals, which can be manipulated so as to show all signal indications. The cars are in charge of examiners, each of whom has an assistant. These men will have charge of all examinations, except those on machinery and air brakes. The cars will also be used for examination of employees on train rules and other subjects.

WINNERS OF THE RAND STOPE-DRILL COMPETITION.

THE winners of the stope-drill competition in the Transvaal are announced, unofficially, by the South African Mining Journal to be the Holman 2⅛x5 inch and the Siskol 2⅜x6 inch. These machines are stated to be practically tied for first place, the next in order being the Chersen. This competition was arranged by the government and the Chamber of Mines and was commenced February 15th, 1909; thus the trials have been continuous for more than a year. There were 21 machines entered originally; of these, eight failed to pass the elimination tests and the actual competition was begun by 13 types of machine; Holman 2¾, Chersen, Holman 2⅛, Climax Imperial, Murphy, New Century OO, Siskol, Waugh, Westphalia and Konomax. The Climax Imperial, Murphy, Waugh and Westphalia were hammer drills, the remainder being of the reciprocating type. The essential difference between the two leading machines is stated to be that the Siskol is the faster running drill while the operating costs are considerably less in the case of the Holman 2⅛ inch.

Monthly statements of progress were made until August, when these were discontinued. At that time, the relative positions of the competitors were widely different from their final standing, illustrating the fact that tests of machines over short periods are not sufficient evidence on which to base a final judgment.

In a recent number of the Journal of the Society of Chemical Industry C. Beadle and H. P. Stevens describe a machine for mechanically testing India rubber. Test pieces are cut from sheets 1 millimeter thick in the form of rings 10 millimeters diameter, with a 5 millimeter hole in the center, and are attached to two iron hooks, one fastened to a stationary block and the other to a sliding block moving horizontally on the base of the machine. A cord passing over a pulley and carrying a light metal bucket is attached to the sliding block. Tension is applied by running water into the vessel at the constant rate of 1,000 grammes per minute, and when the test-ring breaks the water supply is cut off automatically. Elongation is measured by means of a pointer attached to the sliding block and moving over a scale. When rupture occurs the hook falls and releases the indicator, which remains at the point of total elongation.

THE PROCESSES IN COTTON SPINNING II.*

A REVIEW OF AN INTERESTING INDUSTRY.

BY LEON A. HACKETT

Concluded from Supplement No. 1798, page 398.

FLYER-FRAMES.

A STAGE is reached with the completion of the carding process, and also in the drawing process, where the product from the machines is divided into many small lots, as was shown in those processes, in the use of tin cans as a means for the temporary storage of the cotton sliver. In the flyer-frame process, where the next mechanipulation occurs, these small lots are to be further subdivided, and one object of the present process is to arrange a more convenient shape for the cotton in its future handling than that of sliver in cans. The form assumed by the cotton for its storage in the flyer-frame, succeeding to that of sliver in cans, is called roving, and in this shape it is wound around wooden bobbins in many uniform layers like thread on a spool. That it may be more clear what this change is, it may be stated that there is a difference even between cotton sliver and cotton roving, though both may be of the same diameter and weigh the same; and this difference is in a twist which is added to the strand, being put in at the same time the roving is being wound on to the bobbins. Twist in connection with cotton-spinning is used for the purpose of giving strength to the strand, and it does so by producing a closer interlocking or cohesion between the individual fibers, while these in turn act to strengthen the strand as a whole. As applied to the cotton strand, the term "twist" denotes the number of complete turns or twists of the strand in an inch of length.

The three requirements, then, of this process are first, the reduction of the diameter, and this by means of the drawing-rolls; then the addition of a twist to the strand, by means of a mechanism called a flyer; and, lastly, the winding of the roving on a wooden bobbin, a convenient shape for the cotton in its subsequent handling.

In Fig. 6 an end view of three machines used in this process is shown, the first one being the slubber, which is fed with stock from the last drawing process; then the intermediate frame, which is supplied with stock just made into bobbins on the slubber; and lastly the flyer-frame supplied with its stock from the intermediate frame. In each of these three machines the roving is drawn down to a diameter a little finer than the preceding one, while at the same time a slightly increasing number of turns of twist is put into the strand at each stage.

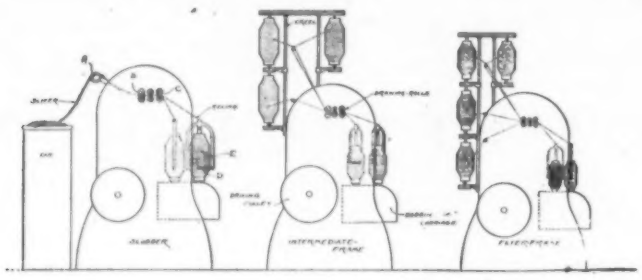
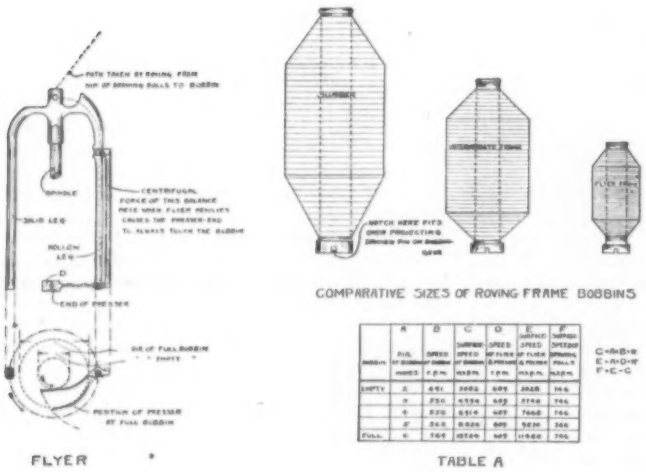


FIG. 6.

In building a roving bobbin the principal parts of the mechanism used in direct connection with the winding are the spindle, bobbin, flyer, presser, and drawing-rolls. Starting with the strand of sliver from a draw-frame in Fig. 6, it is first passed over the bar *A*, through the drawing-rolls *B*, then from *C*, after being attenuated, it passes to the top of a U-shaped piece called a flyer. One leg of this flyer is hollow, and the roving from the top is guided down within the leg to the metal arm *D* attached at right angles to the flyer-leg, which is called a presser. The roving, after passing down the hollow leg, is wound around the presser, and this in turn, as will be shown later, becomes the guide for the roving as it is wound on the wooden bobbin *E*. The other solid leg of the flyer is used merely as a balance to the hollow or working leg.

Consider for the moment the winding arrangement for the roving while just at the point of being put on the bobbin by the flyer and the presser. It is seen from Fig. 8 that the spindle *A*, upon which the flyer is pivoted and held fast, and also the gear upon which the wooden bobbin rests, held fixed to it by the projecting pin *B*, are both concentric. The end of the presser attached to the flyer always presses against the surface of the bobbin, so that if the bobbin and the flyer were arranged with two separately driven trains of gears, and driven at the same speeds and in the same direction, the presser-end would under these conditions touch continuously the same spot on the bobbin during rotation. With the presser-end still touching the bobbin, but now, however, on one of greater size, while it still continues at the same number of revolutions per minute, its surface-speed at the end becomes increased, owing to the point of contact between the bobbin and the end of the presser being farther from the center of rotation. The rotation of the presser-end, *D*, while moving at a constant number of revolutions per minute, has, then, its surface-speed automatically increased as the bobbin fills, while the point of contact between bobbin surface and presser-end is pushed out farther from the center of rotation; so also is the bobbin's surface-speed increased the same amount, with the increase of diam-


CENTRIFUGAL FORCE OF THIS BALANCE WEIGHT WHEN FLYER REVOLVES CAUSES THE PRESSER-END TO ALWAYS FOLLOW THE BOBBIN
SPINDLE
SOLID LEG
HOLLOW LEG
D
END OF PRESSER
DIA. OF FULL BOBBIN
POSITION OF PRESSER AT FULL BOBBIN
FLYER
COMPARATIVE SIZES OF ROVING FRAME BOBBINS

BOBBIN	A DIA. OF BOBBIN INCHES	B SPEED OF BOBBIN R.P.M.	C SURFACE SPEED OF BOBBIN R.P.M.	D SPEED OF FLYER R.P.M.	E SURFACE SPEED OF FLYER & PRESSER R.P.M.	F SURFACE SPEED OF DRAWING ROLLS R.P.M.
EMPTY	2	691	3603	689	3618	104
	3	530	4154	689	5166	104
	4	520	5514	689	7668	104
	5"	548	6926	689	9674	104
FULL	6	569	8574	689	11988	104

C=A×B×π
E=A×D×π
F=E÷C

TABLE A

FIG. 7.

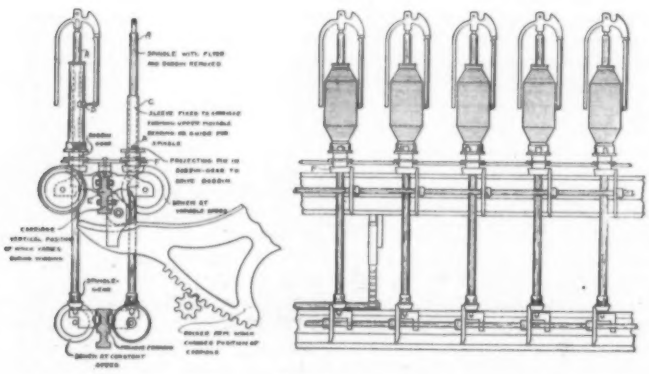

SPINDLE WITH FLYER AND BOBBIN REMOVED
SLEEVE FIXED TO SPINDLE CARRYING DRIVING BEVEL OR WORM FOR SPINDLE
PROJECTION PIN ON BOBBIN-GEAR TO DRIVE BOBBIN
BEVEL OR WORM WHEEL DRIVEN AT CONSTANT SPEED

FIG. 8.

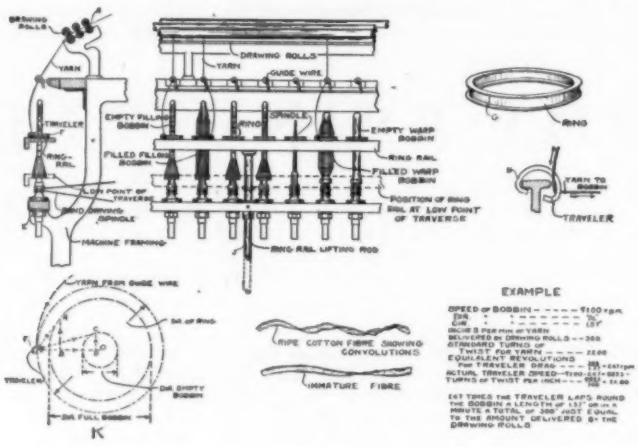


FIG. 9.

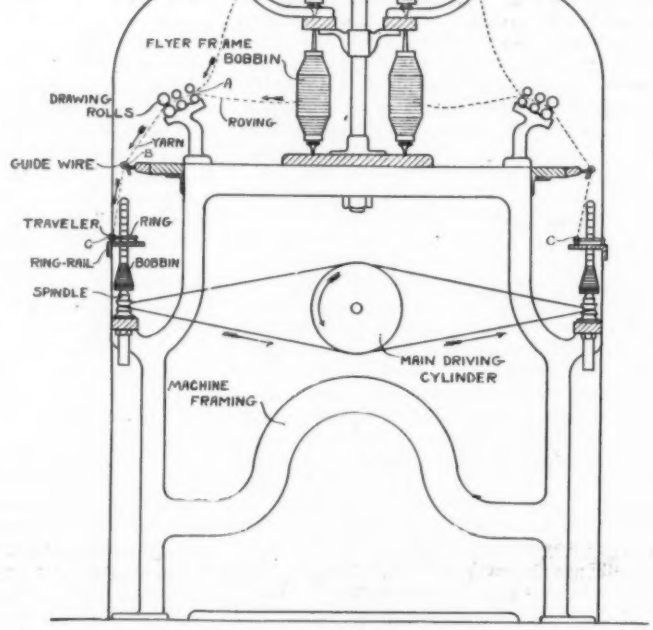


FIG. 10.

* Harvard Engineering Journal.

eter from the roving which is wound around it. In order for the presser-end to effect winding, or to lap the roving around the bobbin, the surface-speed of the presser-end must always be a constant amount in excess of the surface-speed of the bobbin, to equal the amount of roving to be wound on or delivered from the drawing-rolls in a unit of time.

The means by which this adjustment of speeds between presser-end and bobbin is obtained will not be dealt with here, other than to say that it is accomplished with much accuracy through the use of an epicyclic train of gears and hyperbolic cone-drums. It is the principle of the winding just at the bobbin that is the important point to be gathered.

In Table A, Fig. 7, the approximate figures are given for a slubber bobbin, five different diameters during the building having been selected.

As was stated before, on account of the number of small lots of cotton to be treated in an exactly similar way, the machines or frames of the flyer-frame process are made to use the bobbin form of storage for the cotton, and now the machines are also made in multiples, as in the drawing process, where four to six deliveries were combined in a single machine.

In the roving frames, however, the multiplication is carried to a much greater extent, as the multiplication runs as high as from 40 to 200, of which each spindle represents a unit. Much space is saved and convenience of operation and the avoidance of superfluous gearing are obtained by this arrangement, and a machine of the general type indicated in Figs. 6 and 8 is what is used.

In connection with the winding of the roving in uniform layers, it will be noticed in Fig. 8 that the vertical position of the spindle, flyer, and presser does not change, and also that between the spindle and the bobbin there is a sleeve *C* fixed to the carriage *E* that forms the upper guide or bearing for the spindle. This sleeve, so-called *C*, enables the bobbin to slip up and down over the spindle without touching it, while the gear *F*, upon which the bobbin rests, and is driven, moves as a part of the carriage up and down during rotation. The carriage *E*, in passing through its traverse of 10 inches or more, carries with it the bobbins with all their adjacent gearing, and in so doing changes the point of guiding for the roving by the presser-end to the bobbin, so that it is laid on in uniform layers.

SPINNING.

The final operation which converts the cotton roving from the flyer-frame process into yarn is called spinning. This is a process of drawing, combined with an operation that puts a large amount of twist into the strand during the time when winding on a wooden bobbin takes place. The drawing is required to reduce the cotton to the desired degree of fineness; the twist is necessary to give the cotton some appreciable strength. The strand of cotton with this large amount of twist in it is called yarn, in distinction from a roving with its slight amount of twist, and though both might be of the same size and weight per yard, they would be so designated. In size the spinning-bobbin is much smaller than the roving-bobbin, and yet the length of yarn on it is probably many times greater.

The single machine which is used to make this change in the condition of the cotton is called a spinning-frame, and its essential parts to be explained here are shown in Fig. 10. The first of these is the spindle, which is a rod of steel so fashioned, after many modifications leading up to its present form, that it is enabled to be revolved at the high speed of 10,000 revolutions per minute or more, on account largely of a self-contained and self-lubricating bearing. The spindle bearing is fixed in its position on the spinning-frame by the nut *E* (Fig. 9), and is exactly concentric with the ring *F*.

This ring is shown separately at *G*. It performs a most important part in the operation of spinning. Its section, it will be noticed, is nearly that of an I-beam, and over the upper flange during spinning a spring loop of wire, or a clip, called a traveler, is snapped, that it may run around freely thereon.

This traveler is again shown at *H* on an enlarged scale. While swinging around on the ring, it is the means of winding and twisting the yarn as it goes to the bobbin. The bottom flange of the ring is snapped in between little clamps attached to the ring-rail, so that the ring is held fast to it, and, as before, is exactly concentric with the spindle.

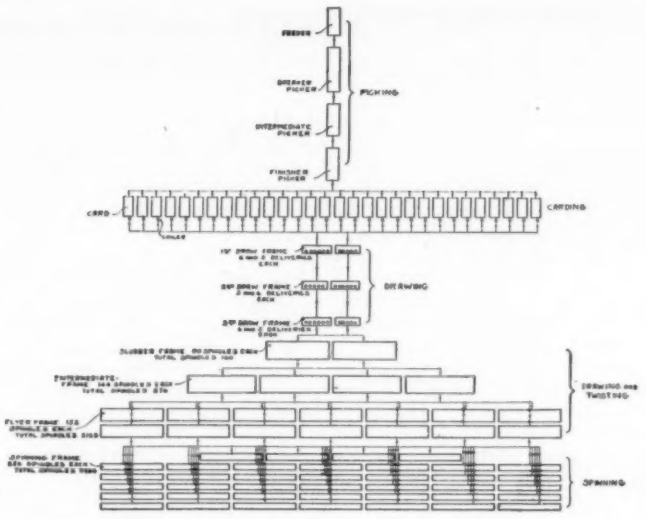


FIG. 11.

By means of a ring-rail lifting rod *J* and a cam motion, the position of this rail, containing a number of rings varying from 75 to 150, is alternately changed slowly up and down, through a traverse of 6 or 7 inches.

Returning now to the operation of the stock through the machine, we shall see, as in the case of the intermediate and flyer-frames, that the cotton, while in process of treatment, was held on bobbins resting in racks or creels, and this is similarly the method used for holding the cotton in the spinning process. From the flyer-frame bobbin, then, which rests in the creel, or rack, of the spinning-frame, the cotton unwinds and is drawn in at the drawing-rolls *A*, Fig. 10. Accelerated surface-speeds of these rolls attenuate the roving to the required fineness of diameter, and then the strand passes from the rolls through the guide wire *B* to the metal clip or traveler *C*, then finally is wound on the wooden bobbin. At the point where the cotton is twisted and in the action of being wound round the bobbin, after leaving the guide wire, the spinning-frame operation has its difficult part to see.

In Fig. 9, at *K*, on a larger scale, the winding and twisting arrangement is more clearly brought out. The winding operation, under certain special conditions, will show better the principle involved than under normal conditions of running. Consider first the traveler to remain stationary on the ring; then the yarn fed through it to the bobbin would be wound on the bobbin at a rate equal to the surface-speed of the bobbin. This for a bare bobbin of the diameter of ½ inch and a spindle-speed of 9,000 revolutions per minute would be nearly 14,150 inches in a minute. The drawing-rolls *A* deliver, however, only about 360 inches in that time, which it is proposed will be wound on the bobbin at the same time. The relation in speeds that meets this large difference in surface-speeds is obtained by allowing the traveler partially to catch up with the spindle or bobbin rotation, by swinging round on the ring, meanwhile paying out yarn through the traveler to the bobbin.

Again take the case of operation when the bobbin and traveler move at the same turns per minute, then there is no winding at all, and instead it is entirely twist that would be put into the yarn. Between these two extremes, a speed for the traveler is found that admits of the necessary winding action to take up the yarn delivered by the drawing-rolls, and the balance of the revolutions is utilized in putting twist into the yarn. The selection of a properly weighted traveler gives this relation in speeds to a nicety, so that the traveler has just sufficient weight to cause it to drag on the ring an amount that would be equivalent in surface-speed to the length of yarn delivered from the drawing-rolls in a minute, while the rest of the speed goes into putting twist into the yarn.

The whole winding scheme by the traveler is virtually the same as the winding on a flyer-frame, except that in the latter case, the corresponding amount of lapping of the roving about the bobbin by the flyer, and the turns of twist put into the roving, are determined mechanically and positively, while, in spinning, the winding and the twist are automatically put in together by the traveler, and without that same precision.

Reference to Fig. 9 shows why it is that the traveler is forced to turn on the ring at all. The pull of the yarn at the bobbin during winding can be divided into two forces, one of which acts along line *BD*, and is ineffective except to pull the traveler toward the center *O* and thereby cause friction between the ring and the traveler. The other force *AB* (or *CD* when the bobbin is empty) acts tangentially to the ring or the bobbin, and is the one that really causes the rotation of the traveler on the ring.

Now, while the yarn is being fed through the traveler to the bobbin and swings round on the ring, the ring being fastened to the ring-rail, which moves up and down, causes the point where the yarn is guided to the bobbin by the traveler to change continually, and so the yarn is laid on in uniform layers.

Spinning-frames like roving-frames operate in multiple form; that is, a large number of lots of cotton are drawn, twisted, and wound on bobbins at the same time, to save the unnecessary duplicating of parts.

The foregoing explanation has embodied the essentials in the various processes of cotton-spinning of interest to the average reader, and a summary in diagram form, together with the numerical relations given in Table B, shows additional points perhaps not appreciated before.

Fig. 11 indicates by the arrows the passage of the stock from one process and one machine to another, on the basis of figures in Table B, and shows especially the increasing multiplication of the machines, necessary to take care of the product at each stage, as the capacity of each unit grows smaller. The figures, also, in Table B are applicable only to a mill running on yarn of a particular size, namely 30's, though the production and particulars of a yarn of any other size would be similar in many respects.

SUMMARY OF OPERATIONS AND PRODUCTION OF MACHINES USED FOR 10000 SPINDLE MILL, SPINNING N° 30

NAME OF MACHINE	CAPACITY IN LBS. PER 10 HOUR DAY	MACHINES REQUIRED ON BASIS OF 10000 SPLD. NUMBER	MACHINES REQUIRED ON BASIS OF 10000 SPLD. NET PRODUCT IN LBS. AFTER ALL OPERATIONS	USUAL % WASTE TAKEN OUT	NAME GIVEN TO THE PRODUCT DELIVERED FROM MACHINE	WEIGHT OF COTTON PER YARD	TURNS OF TWIST PER INCH	NO. OF ENDS DOUBLED INTO ONE	DRAFT OR ATTENUATING ACTION OF MACHINE	SIZE OR HANK OF COTTON
FEEDER	4500	1	2613	3	Raw Cotton		—	—	—	—
BREAKER PICKER	2500	1	2470	3	LAP	7000 GRS OR 16 OZS	—	—	4.	.00119
INTERMEDIATE PICKER	2500	1	2514	2	LAP	7000 GRS OR 16 OZS.	—	4	4	.00119
FINISHER PICKER	2700	1	2466	3	LAP	6450 GRS OR 14 OZS.	—	4	4.50	.00134
CARD	135	15	2354	4	SLIVER	.741 GRS	—	—	115	.154
FIRST DRAW FRAME	135 PER DELIVERY	8	2300		SLIVER	328 "	—	6	6.14	.158
SECOND DRAW FRAME	135 PER DELIVERY	8	2300		SLIVER	52.1 "	—	6	6.88	.160
THIRD DRAW FRAME	135 PER DELIVERY	8	2300		SLIVER	832 "	—	6	6.23	.164
SLUBBER	1060 PER SPINDLE	153	2300		ROVING	1060 "	1.06	—	4.70	78
INTERMEDIATE FRAME	202 PER SPINDLE	726	2300		ROVING	340 "	1.85	2	5.90	5.30
FLYER FRAME	107 PER SPINDLE	2150	2300		ROVING	119 "	3.17	2	6.00	7.00
SPINNING FRAME	23 PER SPINDLE	10000	2300		YARN	28 "	14.91	2	8.57	30.00

* A HANK IS THE NUMBER OF 840 TO LENGTHS IN ONE POUND — IF 840 YDS. THEN NO. 1, IF 7560 YDS. THEN NO. 9

TABLE B

FIG. 12.

Elastic Copal Varnish.—1 part camphor, 4 parts copal, 12 parts ether. The solution only becomes perfectly clear after standing for a long time; it should be allowed to stand in bottles for weeks and then the clear supernatant fluid passed off. At the bottom we have only softened copal, which must be again treated with ½ to ¾ part camphor, 2 parts of copal and 12 parts of ether.

LORD KELVIN.*

HIS WORK IN TELEGRAPHY AND NAVIGATION.

BY PROF. J. A. EWING.

LORD KELVIN'S work was great and many-sided. We might compare it to the cathedral in some crowded mediæval city, where no place can be found commanding a general view. You approach by one narrow street or another, seeing from each only some portion of a particular face of the building. The lecturer might take up the mathematical work of Kelvin in the theory of electrostatics, in the theory of magnetism, in the theory of elasticity, in hydrodynamics, in the wave theory of light; his contributions to thermodynamics, which included the establishment of an absolute scale of temperature and the enunciation of the principle of the dissipation of energy, his experimental work on the electrodynamic quality of metals, his speculations on the structure of matter, his views on the age of the earth, his share in fixing the electrical units; or, on the more practical side, his electrical measuring instruments, from the electrometers of the early days to the ampere balances and wattmeters which he designed when the need for such instruments became apparent with the growth of electrical engineering. Any one of these subjects, or others that might be named, would provide a more than ample text. To-night I have selected two portions of Lord Kelvin's work as the most suitable to bring before you, namely, his work in submarine telegraphy and in navigation. Both of these are practical matters which appeal to members of this institution. They illustrate well the bent of his genius as an engineer. In both of them he made inventions of first-rate importance—inventions which not only met an immediate requirement, but have stood the test of time; and an additional reason for the selection is the personal one that both in telegraphy and navigation it was my good fortune, as one of his young assistants, to see some of his inventions in the making.

His connection with telegraphy had begun long before when he was only thirty years of age. It dates from 1854, and to appreciate rightly the part he began to play then I must ask you to go back as far as 1850, the year of the earliest submarine telegraph. It was in August, 1850, that a line consisting of a single copper wire, insulated by gutta-percha, wound on a great reel on the deck of a steam tug in Dover Harbor, was laid from Dover to Calais. There was no sheathing or protection of any sort; the line was what we should now call a bare core, and so light was it that lead sinkers were attached at every hundred yards to insure its going to the bottom. In a few hours it was cut by the anchor of a fisherman, who took home a piece to show to his family as a curious new kind of seaweed; but during its brief life it gave the operators much food for thought. Accustomed only to the clear, sharp signals of land lines, they could make nothing of those got from the cable, and Mr. Willoughby Smith tells us how at each end of the line it was regretfully concluded that the operator at the other end must have been lunching, not wisely, but too well. This was the earliest experience of the effects of electrostatic induction in retarding the signals and altering their character. The cable is equivalent to an extended Leyden jar of large capacity, and at every application of the sending battery there is a gradual charging up, so that the signal current which arrives at the distant end does not at once reach its full strength; and, further, when the contact with the sending battery stops, the current does not at once cease, but tails off slowly as the cable discharges the electricity it has accumulated. The current accordingly arrives in the character of a wave, slowly rising to a maximum value and then slowly subsiding each time a signal is sent.

In a short cable this causes little trouble; it only makes the process of signaling a little slower, but the instruments which serve on land lines may still be used. A successful Dover-Calais cable properly covered with a protecting sheath was laid in 1851, and was soon followed by other short lines. The general character of the electrostatic charge in a cable was explained by Faraday, and it was experimented on by Latimer Clark in a cable, 110 miles long, laid to connect England with Holland; but no one knew then in what manner the retardation of signals to which it gives rise depended on the electrical characteristics or how it would be affected in cables of different lengths or with different dimensions of core. It was in 1854 that Thomson's attention was directed to the subject by Stokes, following on a conversation at the British Association, and in this way began the connection with submarine telegraphy which was to prove of momentous import.

Thomson attacked the problem with characteristic ardor, and in less than twelve days he sent a complete solution to Stokes, which was published in fuller form in the Proceedings of the Royal Society for May, 1855. In this paper he points out that the effect of electrostatic induction is to make the flow of electricity in a cable correspond to the flow of heat in a solid conductor as investigated mathematically by Fourier. He formulates the equations and draws what is called the *curve of arrival*, the curve, namely, which shows in what manner the current gradually reaches its full value, at the distant end of the cable, when contact with the battery is made at the sending end. He shows how the current falls away when the battery is removed and the cable is put to earth; and how, in cables of different lengths but of the same dimensions of core, the time taken by the current to reach any particular fraction of the full value will vary as the square of the length.

This result of the theory was of fundamental importance. It was also, at the time, of particular interest, for the project was then beginning to be mooted of connecting England and America by wire. The only experience available as to speed of signaling was on short cables, and in passing from them to a line 2,000 miles long the "law of squares," as it was called, seemed at first to give little prospect that signaling across the Atlantic could be accomplished at a speed that would be commercially practicable.

To lay the cable it was coiled on board two ships of war, the British battleship "Agamemnon" and the United States frigate "Niagara." On August 5th, 1857, the shore end was landed at Valencia, and the "Niagara" began to pay out, the intention being that her section should be laid first and the "Agamemnon" should continue the work after making a splice in mid-ocean; but the paying-out gear was very crude; the brake for maintaining a proper tension in the cable was difficult to regulate, and after 300 miles were laid there was a mishap at the brake and the cable parted in 2,000 fathoms. The ships returned to Devonport, the cable was stored for the winter, new machinery was designed, and some 700 miles of fresh cable were manufactured against the next attempt, to be made in the following year.

Thomson had joined the expedition at the request of his brother directors, and was on board the "Agamemnon." He came back full of ideas as to both the electrical and the mechanical sides of the great problem. On the mechanical side he had worked out, for the first time, the theory of the forces concerned in the laying and lifting of deep-sea cables; this was published almost immediately after his return. Let me give you a brief sketch of the results of this theory.

A cable paid out from a ship going at uniform speed does not hang as a catenary, but takes the form, as it sinks, of a straight line stretching at a uniform slope from the ship's wake to the point far in the rear at which it touches the bottom. This is because each part of the cable in sinking through the water attains almost immediately a constant velocity of descent against the resistance which the water opposes to its motion. Imagine a ball, heavier than water, to be dropped from a ship. It will, after sinking a foot or two, attain a practically uniform velocity, and keep that until it reaches the bottom. Imagine now a ship to drop a series of such balls, at regular intervals, while she steams ahead at a steady speed. At any instant the depth through which each ball has sunk will be proportional to the time which has passed since it was dropped, and therefore to the distance run by the ship, and hence a line joining the successive balls will be a line of uniform slope. The continuous cable behaves in this respect like the row of balls, but with this important difference. Each ball sinks vertically; it has no tendency to do anything else; but the cable tends, not only to sink, but to glide along the direction of its own length, just as a rope resting on an inclined plane tends to glide down it. A certain amount of such gliding is desirable, indeed necessary, for it secures that the cable will be laid with a sufficient percentage of slack to accommodate itself to any inequalities on the bottom, and to provide for the possibility of its being raised should that be required. It is the function of the paying-out brake to apply just so much retarding force as will allow the right amount of this gliding to take place, and not too much. As cables are actually laid, there may be 10 or 12 per cent of slack, and this means a considerable velocity of gliding motion. In a cable of the type which was afterward successfully laid across the Atlantic, the straight line had a slope of about 1 in 8½—in other words, with a depth of two miles there were seventeen miles from the ship to the place where it touched bottom. On the gliding motion down this long slope the frictional resistance of the water is an important factor; it reduces very much the retarding force needed at the brake. If it were simply a question of holding the cable from gliding down the slope at all, the retarding force would be equal to the weight, in water, of a length of cable equal to the depth. In fact, however, it is about half that, the other half being accounted for by the frictional resistance the cable experiences in gliding down the slope.

In the early summer of 1858 the cable squadron was again ready to put to sea. New paying-out brakes had been devised. Thomson had succeeded, with much difficulty, in getting systematic tests of the conductivity established during the manufacture of the additional 700 miles. Most important of all, he had invented a new signaling and testing instrument which was to make Atlantic telegraphy commercially practicable. This was the mirror galvanometer, the first description of which is found in his patent of 1858.

We have no time to linger over the story of the cable of 1858. This time the two ships, after encountering a storm of great severity, in which the coiled cable suffered severe damage, met in mid ocean, spliced the cable, and began to pay out simultaneously, the "Agamemnon" steaming toward Ireland and the "Niagara" toward Newfoundland. The cable broke when only six miles were paid out. Again the ships met to make a fresh splice, and again the cable failed when some eighty miles had run out. A third attempt promised better, for some 200 miles were laid, when again the cable broke, this time at a place where it had been injured in the storm. The ships returned to Queenstown. Bright, Thomson, and the other leaders, disappointed but not discouraged, advised the board to order a fresh attempt. Their advice was taken. The ships once more met at the mid-ocean rendezvous, and this time success crowned their efforts. On August 5th both ships completed their task, and the ends of the cable were brought to land.

Scarcely had the enthusiasm awakened by this great event began to subside when it was apparent that all was not well. The Irish end of the cable had been handed over to Mr. Whitehouse, who attempted with little or no success to establish communication by means of his own signaling instruments. It was only when the galvanometer of Thomson was resorted to, with a simple Daniell battery to send the current, that messages were transmitted. The board, dissatisfied with Whitehouse's action, directed Thomson to take complete charge. Various important messages passed, but the tests showed that the insulation of the cable had broken down; a bad fault developed, which had doubtless been intensified, if not produced, by the high-tension induction coils used by Whitehouse. The signals grew more and more feeble, and in a few weeks the cable altogether ceased to speak.

It never spoke again, and not until 1865 was the attempt made to lay a new Atlantic cable. By that time much had been accomplished. It was in the intervening years that the work of establishing standards for electrical measurement was undertaken by a committee of the British Association. The committee was appointed at the instance of Thomson, and he took a prominent part in its work. Besides this, the cable engineers were busy, and were gaining experience from lines laid in other places. Methods of systematic testing were devised; a type of cable was designed which was better adapted than before to bear the strain of laying, and especially the much severer strain of picking up, and material improvements were made in the paying-out machinery.

In 1865 the "Great Eastern" was available for laying the cable. Thomson, along with Cromwell Varley, went as a consulting expert on behalf of the company. Twelve hundred miles were successfully laid, and then a fault showed itself; picking up was begun, but in maneuvering the ship the cable parted in deep water. Attempts were made to recover it by grappling; three times it was hooked and brought part of the way to the surface, but the shackles used to couple up successive lengths of the grappling rope were too weak to stand the strain. Grapple, rope

* From the second Kelvin lecture, delivered at the Institution of Electrical Engineers.

and cable were lost, and the ship returned with the task unfinished, but with everyone now full of confidence, not only that a sound cable could be laid, but that the lost cable could be found and lifted.

In 1866 the thing was done; an entirely new cable was laid with complete success, and then the "Great Eastern" with her consorts proceeded to the lost end of the cable of 1865, and began once more to fish in water more than 2,000 fathoms deep. A fortnight passed before the watchers at Valencia saw any sign; then the spot of light began to flicker, and presently the flickerings shaped themselves into letters and words. The cable had awakened to life. A few days more and it too was complete.

Throughout the operations Thomson was in the ship; Varley remained at Valencia. Thanks to their labors, and to those of Mr. Willoughby Smith, the contractors' electrician, the appliances for testing on board ship had been brought to a degree of perfection that left nothing to be desired. By this time it was generally recognized that the credit for Atlantic telegraphy, regarded as an electrical achievement, belonged to Thomson, though in his characteristic manner he would, when speaking of the subject, dwell on the parts played by others. Along with Mr. Canning, the engineer of the expedition, and Captain Anderson, who commanded the "Great Eastern," he received the honor of knighthood.

For a time his mirror galvanometer remained the only instrument by which conversation could be carried on. He now proceeded to design a substitute for it which should give a record of the successive electric impulses instead of merely exhibiting them to the watchful eye of a skilled clerk. To secure greater power in the movement of the indicator he inverted the function of magnet and coil, making the coil the movable piece and the magnet the fixed piece. The coil was, therefore, made very light; the magnet, which being stationary might now be very heavy, was made exceedingly strong, and was arranged so that the coil lay in an intense field between its poles. The movement of the coil actuated a very light pointer, or rather pen, in the form of a siphon-shaped tube of fine drawn glass, from which ink was deposited on a running paper band. Here we find the earliest example of the moving coil type of galvanometer, often called the D'Arsonval type by those who do not recognize its real origin.

It is a type now familiar in many practical instruments for the measurement of direct-current amperes and volts; but an important element in the invention is still to be named. It was essential that the glass pen should write without friction, and Thomson effected this by the happy device of electrifying the ink so that the ink and the paper attracted one another, with the result that the siphon was maintained in a constant state of rapid vibration, alternately advancing to the paper to deposit a minute drop of ink and then springing back, but all the time free to follow, without friction, the movements of the coil in obedience to the electric impulses arriving through the cable. Dynamically the siphon recorder has to satisfy the same conditions as those that determined the design of the mirror galvanometer. It draws on the moving strip of paper a curve of arrival for every one of the successive currents of which the signals are composed.

To this day the recorder remains in universal use as the standard instrument in submarine telegraphy. It has been simplified by the substitution of permanent field magnets for electromagnets, and by the use of an electromagnetic vibrator for the siphon instead of electrification—changes which were made in later years by Thomson himself.

(To be concluded.)

LIGHTNING.

A SUMMARY OF RECENT STUDIES.

BY PROF. ELLERY B. PAINE, M. S., E. E., UNIVERSITY OF ILLINOIS.

A CENTURY and a half ago when Franklin made his famous kite experiment it was generally believed that lightning was the explosion of vapors which collected in the atmosphere under certain conditions. Franklin's proof that lightning is electrical in its nature stopped much speculation over the chemical composition of those vapors and the way in which they became ignited to produce the lightning explosions. Since Franklin's time scientists have considered lightning similar to the sparks of experimental electrical apparatus except that the lightning is on a vastly magnified scale.

During the last hundred years many men have tried to learn the secret of atmospheric electrification. Many hypotheses have been proposed in explanation of the electric charge of the air. Friction of air currents, evaporation of moisture, dashing of ocean waves against the rocky shores are known to produce electrification. We must admit, however, that we do not understand what produces atmospheric electrification.

Many who have written on the subject have classified lightning in three forms: Zigzag, sheet, and ball lightning. We now think sheet lightning is unlike the first named form only in having the direct light from the flash hidden from the eye. In this form of lightning one sees the light reflected from the clouds. Many marvelous accounts of the slowly moving ball lightning have been recorded. Modern scientists who had never seen this form of lightning were inclined to be skeptical. The discovery by Prof. Righi of Bologna[1] of a method of producing such discharges experimentally leaves us little ground for doubting the existence of ball or globular lightning.

Dove was perhaps the first to attempt to measure the time taken for a lightning stroke.[2] He used a rapidly revolving disk marked with colored sectors. He discovered that lightning discharges are usually made up of several component flashes. His experiments showed that each separate flash was apparently instantaneous. Four years ago Schmidt made a similar investigation[3] and found that the separate flashes were completed in less than 1-30000 second.

In recent years the camera has been of much value in lightning study. The first work done in photographing lightning appears to have been that of Prof. Keyser at Bonn.[4] Photographs of lightning taken with stationary cameras sometimes showed the discharge separated into its component flashes by the side drift of the air currents. This suggested to Prof. Weber of Kiel the use of a revolving camera which would allow the impressions of the various discharges to be still more widely separated on the photographic plate.[5] Later Dr. Walter of Hamburg developed and used a rotating camera.[6] Similar work has been done in the United States by Larson.[7]

The camera investigations have shown that lightning strokes are usually composed of not less than five or six discharges along nearly the same path. Some strokes are made up of as many as forty flashes. The time required for complete discharge sometimes is as great as 0.6 second.

In 1858 Feddersen found proof of the oscillatory nature of Leyden jar discharges. It is thought that lightning discharges also are oscillatory but no direct proof has ever been made. Experiments made to solve this problem have not been conclusive.[8]

Estimates of the voltage necessary for lightning, based on data obtained from such discharges as may be produced in the laboratory, lead to values which appear unreasonably large. Lodge estimates the potential difference required for a lightning stroke one mile long as 5,000 million volts.[9] Steinmetz calls attention to the fact that with such a potential difference as this the corona effect would be very marked. It is probable that long strokes may take place with voltages far smaller than the estimate quoted. It is known that a dielectric breaks down at a point where the potential gradient at that place is too great. That is, a dielectric cannot withstand an electric stress greater than that caused by a certain number of volts per inch. The exact value of the limiting potential gradient varies with the character of the dielectric. If in the atmosphere we have, even for a short distance, a too great potential gradient, discharge will take place. Because of the lowering of the potential at one end of the discharge path the potential gradient may become too great at that point, so that the discharge extends over another space. In this way it appears reasonable that a long discharge may result, although the initial difference of potential is sufficient to cause discharge over only a much shorter path. This explains how a stroke of lightning may occur wholly within a single cloud. It was formerly thought that lightning occurred only between two clouds or between cloud and earth.

Hence we see that the condition needed for lightning discharge is that the potential gradient along a path through the atmosphere be greater than the air can withstand.

It has been found that under normal conditions the potential gradient along a vertical line from the earth's surface is several hundred volts per foot. As stated before, we are not certain what causes this change of potential at different elevations. Particles of water formed by condensation of moisture in the atmosphere will have potentials equal to that of the air at the place of formation. As numbers of these small particles combine into larger drops the potential of the drop increases with increase of size, because the capacity of the drop increases only as the radius, while the total quantity of electricity increases as the mass or the third power of the radius. Hence great condensation will cause the potential of the drops of water to become greater than the potential of drops at a point of less condensation. If we have within a cloud quite unequal condensation at various points we may have potential gradients so great that the air along certain paths is broken down. We have these conditions most frequently in the case of the gusty clouds formed near the earth on hot summer days.

The great heating effect of lightning indicates that its current strength is high. Dr. Prockels has investigated the strength of current in lightning rods which had been struck by lightning.[10] The tests reported indicate currents of ten thousand amperes or more.

The total energy of a single flash of lightning has been estimated by Steinmetz as 10,000 kilowatt seconds. This estimate is based on the energy required to produce illumination equal to that given during a lightning stroke.[11]

Lodge arrives at about the same result from the calculation of the amount of energy stored in a certain volume of air due to the maximum electric tension air is able to withstand.

Our knowledge of lightning is far from complete. The loss of life and property each year because of lightning is large. In the United States alone the loss, according to government records, amounts to several hundred lives and between one and two million dollars worth of property. One of the great problems of the electrical engineer is the protection of electrical apparatus from lightning troubles. This problem has assumed greater proportions since the use of long distance high potential transmission lines. A better understanding of lightning is much to be desired.—The Technograph, published by the Engineering Societies of the University of Illinois.

[1] Electrical Review, London, April 3, 1896.
[2] Poggendorff Annalen, 1835. S. 371.
[3] Elektrotechnische Zeitschrift Sept. 28, 1905.
[4] Wiedermann Annalen, 1885. P. 131.
[5] Bericht der Kolgl. Akad. 1889. P. 781.
[6] Physikalische Zeitschrift 3, S. 168.
[7] Annual Report Smithsonian Institution, 1905.
[8] Physikalische Zeitschrift 2 P. 715.
[9] Lightning Conductors and Lightning Guards. Page 9.
[10] Wiedemann's Annalen. 65 S. 458.
[11] National Electric Light Association, 1907. v. 1, P. 361.

THE ELASTICITY OF TIMBER.

NUMEROUS experiments have been made in Europe, America, and Australia for the purpose, says The Builder, of obtaining reliable data as to the physical properties of timber employed in building and architectural construction. Nevertheless, few records are available enabling designers to take into account the coefficient of elasticity in a direction perpendicular to the fibers. A series of tests conducted by Signor Panetti in the laboratory of the Naval College at Genoa bring out clearly the difference between the coefficient of elasticity of timber when tested parallel to the fibers, and the value obtaining when the material is tested perpendicularly to the fibers. The tests were conducted on prisms of Piedmontese oak, 2¾ inches square, some with the fibers parallel to the length of 78 inches, and others with the fibers perpendicular to the length of 39 inches. Those of the first kind were subjected to compressive stress gradually increased up to 3,770 pounds per square inch, with the result that the coefficient of elasticity was found to range from 1,720,000 pounds per square inch for stresses within ordinary working limits, down to 1,250,000 for the stress at the elastic limit. Prisms of the second kind were subjected to much smaller pressures, and it is stated that the corresponding deformations showed the maximum value of the elastic coefficient to be not greater than 117,000 pounds per square inch. Judged by these results the compressibility of timber across the grain is about fifteen times its compressibility with the grain. It should also be noted that the elastic limit is approximately marked by a stress equal to one-fifth that at the elastic limit of timber tested with the grain.

OIL FIELD PHENOMENA.*

THE OCCURRENCE AND RECOVERY OF PETROLEUM.

BY A. BEEBY THOMPSON, A.MI., MECH. E., F.G.S.

In few directions are there greater inducements for young enterprising engineers than in petroleum mining which during recent years has advanced with such rapid strides that oil producers everywhere feel the need for trained engineers capable of occupying the many positions of trust which naturally arise.

The oil industry is still in its infancy although so much has been done during the last few years in developing new regions in all parts of the earth; and for many years enterprises which often pay such phenomenal returns upon capital must prove an attractive source of investment. A brief review of the mode of occurrence of petroleum and the means adopted in its search and recovery may be the best manner of eliciting interest in a subject which is daily assuming greater importance in the world's progress and in which the need for specially trained engineers is annually being more felt.

Petroleum is a liquid, composed of a mixture of a great number of hydrocarbons. Rarely are two samples of petroleum from different districts composed of the same hydrocarbons, and even in neighboring wells the product is often very dissimilar. The exact composition of petroleum is difficult to determine as when subjected to heat the constituent hydrocarbons break up into other members of the series or become converted into entirely different series of hydrocarbons. Even when exposed to atmospheric influences petroleum undergoes changes through evaporation and oxidation. The subject of the constitution of petroleum is, however, much too large to discuss in a brief article.

Porous strata in certain localities on the earth are charged with petroleum, and where they outcrop or even closely approach the surface a steady exudation of oil has often led to the formation of beds of asphalt as a result of evaporation and oxidation. It is such indications which have often attracted the attention of prospectors and led to drilling of wells for oil. In other cases the occurrence of strata charged with petroleum far below the surface is indicated by issues of inflammable gas in the vicinity of sharply inflected beds which have been fissured sufficiently to allow the gas and oil contained in their pores to escape. At other times where the inclined petroliferous beds outcrop there is nothing further to betray the petroliferous character of strata than a brown discoloration of occasional porous bands, which discoloration is frequently concealed by a bleaching action and which would mislead any casual observer.

ranean distribution differs from all other minerals and water, and its movements are largely influenced by structural features which the containing beds assume. Where sedimentary strata containing petroleum and gas have been thrust into folds as a result of earth movements a steady separation and redistribution of the containing fluid has often occurred and led to the

RUSSIAN FLOWING WELL.

segregation of great volumes of oil and gas in favored localities.

One of the usual structures imparted to strata by terrestrial crushing forces is an anticline and syncline, and where such conditions characterize beds in which petroleum has been secreted, and suitable impervious cappings exist, the oil and gas has steadily mounted to the summit of the anticlines while any water present in the series has largely accumulated in the synclines, thereby often displacing oil and forcing it into the anticlines. The process of segregation has doubtless been slow, and in many cases the great accumulations of oil probably attained their existing location long before the formations reached the present severe inclination they often partake, and before faults and disturbances isolated sections of strata.

Many of the anticlines in which great volumes of oil are stored are exceedingly sharp inflections with sides that sometimes reach a nearly vertical inclination, and in such cases the beds have been usually so much fractured that petroleum and gas found their way from the true oil horizon to sedimentary strata of a newer age above and impregnated porous beds which were formerly barren. Such secondary deposits of petroleum are not uncommon and they often yield remunerative productions of oil and gas when perforated by drilling.

The ideal structure of a regular anticline with gently sloping sides, beds little fractured and disturbed, and suitable impervious covering of clays or shales, is rarely found, but where less perfect structures exist, enormous volumes of gas and oil have accumulated and can be reached by drilling. In the majority of cases surface disintegration has proceeded so far since the present form was imparted to the beds, that the summits of the anticlines have long disappeared, leaving outcropping productive strata on the surface. Under such circumstances it might be argued that the oil should have all escaped from the beds if such subterranean movements as those described are in progress; but several forces are operative in preventing this. In the first place the strata have usually been faulted since the interchange of oil and water, preventing thereby the continuity of a single stratum over a large area; secondly, the water which was often the transporting agent during the process of interchange has largely departed or sunk into the synclinals; and thirdly, the oxidation of petroleum in the vicinity of the outcropping oil beds has often led to the production of an impervious residue (like asphalt) which acts as a partial seal to the further escape of the contained fluids.

There is, however, ample demonstration that there are movements of oil and gas still proceeding where oil-bearing strata are inclined or fractured; and further, the effect of earth movements on the subterranean distribution of mineral oils has often been observed. In the United States, oil-field phenomena are nowhere displayed on the extensive scale they are in some other countries. In parts of California considerable deposits of oil residues or asphalt testify to the escape of great volumes of oil from the earth, but it is in Russia, Burma and the East and West Indies that the greatest exhibits of natural phenomena may be seen.

Around the Baku oil fields of Russia, hills of asphalt are to be seen, and the constant escape of the heavy fluid may be watched in many localities. At certain spots volumes of gas steadily emerge from cracks in the surface, and where the beds are only covered by an inconsiderable depth of damp clay, the escaping gas produces a puddled mass which has been ejected until hills several hundred feet in height have been formed. The activity is still maintained, and periodically when an unusually long period of quiescence has preceded

RUSSIAN FLOWING WELLS.

Some of the above phenomena surrounding the occurrence of petroleum are often to be seen on an extensive scale where highly productive oil strata reach or closely approach the surface under suitable conditions. Petroleum when present in large quantities is always accompanied by great quantities of dissolved gaseous hydrocarbons, consequently its subter-

*Yale Scientific Monthly.

and the gas has acquired a high pressure, tens of thousands of tons of clay are ejected in a few hours and many acres of land covered.

At other points where no moist clay covers the beds, great outbursts of gas, sometimes accompanied by oil, occur, and numerous holes sufficiently large to admit the body of a man are opened. In the West and East

MUD VOLCANO NEAR VARSNIKOVSKAR IN THE TAMAN PENINSULA. SOUTH RUSSIA.

Indies much the same conditions exist, and for miles in the tropical jungles along the crests of anticlines may be observed both heavy oil and gas steadily issuing from the earth forming cones of asphalt mixed with earthy matter with which it is usually associated.

Exceptional activity is usually displayed during earthquakes in such localities. At the great earthquake of Schemakha in the Caucasus in 1902, inflammable gases emerged from fissures in the earth and becoming ignited greatly added to the terror of the situation; and in the Arakan Island, off the coast of Burma, the mud volcanoes usually develop great activity at periods of seismic disturbances.

Similar eruptions occur beneath the sea where inclined oil-bearing strata are submerged. Thus in the Caspian Sea, there are localities where great volumes of escaping gas agitate the water so violently that small boats have been capsized. Off the Klias Peninsula of Borneo, amid the Araken Islands of Burma and in the Caspian Sea, sufficient argillaceous matter has been ejected at the bottom of the ocean to form islands on which a landing of sailors has been effected, but in such cases the islands have usually been gradually washed away as they were entirely composed of soft puddled clay which could not long withstand the action of waves.

The Pitch Lake of Trinidad is an illustration of what nature can perform under favored circumstances. Within a basin, with a surface area of 127 acres, created by the disintegration of material through the agency of escaping gas and oil, no less than 10,000,000 tons of an emulsified product of oil, water and siliceous matter has been produced from oil escaping from inclined oil-bearing strata. To-day wells sunk close to the lake are yielding large supplies of oil, demonstrating, if such proof were necessary, the origin of the asphalt.

The above very incomplete outline of some of the phenomena associated with the occurrence of oil, will convey an idea of the interest in which such a subject is shrouded, and the phenomena connected with the extraction of petroleum are no less interesting.

Petroleum in commercial quantities is almost exclusively restricted to sedimentary strata, and is principally confined to sands stratified with clays or shales in certain horizons. In order to penetrate the productive zone at a depth sufficiently removed from the surface or outcrops to obtain remunerative supplies of oil, a considerable depth of unproductive sedimentary strata has usually to be pierced before the oil beds are reached. In some cases the thickness of strata within which oil is found at intervals reaches several thousand feet, wherein most porous beds prove productive, but usually the oil is strictly confined to certain definite horizons which can only be ascertained by trial.

Some of the Eastern oils of America are obtained from beds of dolomite, but most of the petroleum of the world is drawn from sands and sandstones of varying quality, distributed amid argillaceous shales.

Oil wells are to-day almost exclusively drilled, the process in use depending upon local conditions. In Roumania alone are wells still dug by hand often to a depth of 400 feet by men skilled by many years of practice in this particular and dangerous work. In the design of machinery and tools to drill to depths of 1,000 to 3,000 feet great ingenuity and skill has been directed, and each year improved plant enables quicker progress to be made. In many fields where the strata are reasonably compact and not excessively hard, from 40 to 100 feet per 24 hours can be penetrated with 8 inch to 10 inch tools, whereas in less favorable strata the rate of progress may not exceed an average of 5 to 10 feet daily.

Water sources have sometimes to be excluded before the productive oil beds have been reached, as neglect to take this precaution often results in ruined wells through the flooding of the oil stratum. Operations for the exclusion of water are generally expensive and difficult, especially where there is a paucity of thick impervious beds above the oil source into which the lining tubes can be firmly driven.

The cost of drilling oil wells varies greatly. In the Petrolea oil fields of Ontario, Canada, where most of the wells only reach a maximum of 500 feet, the cost does not exceed $500. In Pennsylvania and the Eastern oil field of the United States the cost may not exceed $5,000 for wells 2,000 feet deep as also in parts of California, but in other Californian oil fields where drilling is more difficult, and in Roumania and Galicia, wells 2,000 to 3,000 feet deep often entail an expenditure of from $25,000 to $30,000. In the Baku oil fields of Russia where exceptional difficulties are encountered, wells of 2,000 to 2,500 feet usually cost from $40,000 to $50,000 and take from 12 to 18 months to complete.

The penetration of an oil source is generally indicated by an escape of gas and an influx of oil into the well. Where water is present in the hole the existence of oil may be concealed, and some experience is necessary to decide whether an oil source has been entered. In some cases the striking of a virgin oil source leads to such a violent expulsion of oil, gas and earthy matter that the drilling tools are blown from the borehole and the derrick shattered. Occasionally gas alone is expelled at a pressure which defies all measures undertaken for its control, and for weeks, months and even years, wells in Borneo have been left discharging gas at the rate of many million cubic feet daily before they could be returned to and carried to the oil sources beneath.

Sometimes the oil is contained in hard rock which will not deliver up its contents until it is shattered by blasting with a high explosive.

The most wonderful discharges of oil and gas were witnessed in the early days of the Baku oil fields, where individual wells have in the course of a few months yielded more petroleum than tens of thousands of wells located in less prolific territory.

In the year 1898 one well in Bibi-Eibat, Baku, produced 3,500,000 barrels in 30 days or 117,000 barrels daily. At that period some thousands of wells in the United States were collectively yielding 150,000 barrels daily, little more than the product of one well in Russia. In the same year one plot of 27 acres in the Baku district operated by an English company gave 7,750,500 barrels of oil from 11 wells.

From the early Baku wells oil was ejected with such impetuosity and was accompanied by so much sand, that steel blocks 12 inches thick placed over the mouth of the well to deflect the flow were perforated in a few hours and had to be replaced. The casing with which the wells were lined was often torn to shreds and eventually collapsed, and hundreds of thousands of tons of sand which accumulated in the vicinity necessitated the services of large bodies of workmen to direct the rivers of oil to surface depressions where it would be temporarily stored.

Instead of these great wells rapidly exhausting the surrounding territory as might have been expected, they apparently caused the opposite effect by producing areas of low density through the removal of so much sand, into which the oil from far around readily infiltrated. Increased impregnation was also aided by the excessive vibration the earth sustained in the vicinity during these violent eruptions, the equivalent result of "torpedoing" in hard rock being a consequence. For miles round the roar of the escaping gas and oil could be heard, and for a wide radius the earth quivered as masses of sand forced into the casing, alternately and momentarily checked the flow and were expelled.

The only oil wells which have approached in violence and productivity those of Russia, have been occasional strikes in Borneo and Mexico. A great well near Tampico, Mexico, yielded, it is estimated in 1908, no less than 3,000,000 barrels in two months. The eruption was so violent that the earth was shattered for a wide radius around and eventually a great seething crater with an area of 25 acres was formed into which the derrick and machinery disappeared. The well eventually turned to water and great streams of sulphur water have since flowed from the crater. It is said that 2,000,000 tons of solid matter was ejected from the well.

In Texas and California great gushing wells have been struck which have yielded for a while 10,000 to 20,000 and even up to 60,000 barrels a day, but usually control has been less difficult on account of the smaller proportion of sand commingled with the oil.

The dangers attending such ejections of inflammable material may be surmised, even when the most elaborate precautions for safety are taken. For weeks great wells which have accidentally ignited in Russia have burnt and consumed from 70,000 to 100,000 barrels of oil daily, producing a conflagration which has illuminated an area of many square miles at night. The great heat and fierceness of projection have prevented any attempts at extinction until the pressure decreased, or the well became partly plugged with sand.

Many such conflagrations have been the result of a spark through ejected stones striking ironwork in the derrick, but often the destruction of the derrick at the first eruption has caused the electric wires to break and so a spark which led to an instant explosion.

In one case where a great gusher had been burning for some weeks, water entered the well and mixed with

AN ILLINOIS OIL WELL.

OIL WELLS ON THE COAST.

the expelled oil. The great heat vaporized the water in its ascent in the flame causing periodical explosions at a great altitude which ejected unconsumed oil into the atmosphere, where winds carried it for many miles over the country deluging property. Where wells of less violence became ignited their extinction is frequently accomplished by projecting into the flame great volumes of some non-combustible, such as steam or carbon dioxide. Steam has been most successfully employed by directing a large number of high pressure steam jets instantly on to the flame, the rapidly expanding steam preventing access of the necessary amount of air to sustain combustion.

At other times the ground has been tunneled and the casing squeezed flat by hydraulic power.

When wells flow naturally under reasonable pressure and the oil is not accompanied by much sand, the output is controlled by valves and the product led off as required. In some fields the closing of flowing wells has led to disastrous results, as on reopening no oil has been found, or water has been admitted to the well. This occasional result is probably due to the high closed pressure which has either so closely compacted the channels through which the oil entered the well that its re-entry was impossible, or to the gas forcing an outlet behind the casing into water bearing strata. It is generally preferable to control the output, but not entirely to check the discharge of a flowing well.

After a period of natural flowing the length of which is always uncertain, the oil has to be raised from the wells by artificial means. The most common plan is to pump the oil by means of a cylindrical pump lowered on tubing to near the base of the well; the pump plunger being operated by rods which are given a reciprocating motion at the surface.

In the design of pumps to suit local conditions, and in the mechanical arrangements of operating the pumps and providing power, endless openings for individuality exist, and engineers may find many opportunities for a display of originality and skill.

Local conditions must determine whether gas, oil, steam engines or electric motors are best adapted as a source of power, and local circumstances must decide whether the wells shall be pumped singly by separate motors or in groups by central stations from which the power is transmitted by tensional rods called "jerker lines."

In special cases of danger compressed air has been used as power, and in numerous instances where high pressure gas has been struck the gas has been led direct to steam engines and power obtained in this way. Under such circumstances the cooling effect of the expanding gas causes so low a temperature that even in the tropics the engines become coated with a mass of ice as the moisture condenses and freezes around the cylinders.

For the supply of power to the Baku and Roumanian oil fields fine modern electric generating stations have been erected. In the Baku stations nearly 20,000 horsepower is generated by three phase alternators for a tension of 2,000 and 6,000 volts. Both steam turbines and vertical reciprocating steam engines are used, and for the long distance transmission the voltage is transformed to 20,000 volts. The cost of electrical power is based on the price of oil.

In the Russian and a few other oil fields so much sand is mingled with the oil that pumps cannot be used to any considerable extent, and the oil is raised by bailing. Bailers are cylindrical vessels from 10 to 40 feet in length and 6 inches to 14 inches in diameter. They are fitted with a valve at their lower extremity opening inward and they are lowered and raised on wire ropes by means of a winding drum driven by a motor. The speed of bailing is often over 1,000 feet per minute and the quantity of liquid raised frequently exceeds 2,000 barrels a day.

Another interesting process of raising oil which is sometimes used where both sand and water accompany the oil, is the air-lift. Air is usually led down the well between two tubes, often 2½-inch and 4-inch, the outer of which extends to the base of the well, whereas the inner only reaches to within about 100 feet of the base. Air enters the 2½-inch tube at its lower extremity, mixes with the liquid which it aerates sufficiently to cause it to flow at the surface. With a submergence of the air inlet equal to at least twice the direct lift from the surface of liquid to the surface, about 1 volume of liquid can be raised to 11 volumes of free air, but with a depressed level the efficiency falls greatly.

The actual output and ratio of air to liquid is naturally to some extent dependent upon the density of oil, the proportion of oil, water and sand, as well as the quantity of gas, but below 50 per cent submergence the efficiency becomes very low.

A NEW AGRICULTURAL INVESTIGATION.

ISOLATING HARMFUL ORGANIC SUBSTANCES IN THE SOIL.

THE isolation of harmful organic substances from soil is discussed in a bulletin issued by the Bureau of Soils of the Department of Agriculture by Oswald Schreiner and Howard S. Reed. Previous investigations of this subject have indicated that soils may be infertile or "exhausted" because of the presence in them of organic compounds injurious to plants.

The paper deals with the isolation and identification of some of the inhibitory or injurious compounds in such infertile soils. It is almost self-evident that where such bodies give rise to infertile soils there can be intelligent scientific treatment of such soils only when the nature and properties of these bodies are known. The isolation and identification of these bodies is the first step in the attainment of this knowledge.

In approaching this problem, which is an exceedingly complex one, it was found necessary to review briefly the knowledge of the origin of the organic matter in the soil. This review shows that the soil organic matter arises through the decay of organic compounds of vegetable and animal origin; that among these compounds are many of well-known composition and constitution which get into the soil and may even persist for a time, and that many compounds which are formed from these in the process of decay are likewise well established as definite chemical compounds.

When the effect of these compounds which are known to get into the soil or to be formed in the soil is considered, it is found that many of them have been shown to be harmful to plants, some even when in very small amounts. On the other hand, it is not yet possible to trace any general relation between the harmful properties and the chemical composition or constitution, and consequently it is not possible to determine the effect of any compound on plants except by experiment.

In addition to known products of vegetable and animal origin and their products of decay, it is possible that still other compounds are produced and exist in the soil about which there is no knowledge, not even of a speculative kind. In view of these facts, it was found necessary to consider briefly the present knowledge of soil organic matter in general. It was found that although the organic matter in soils is an important ingredient, amounting in most cases to many tons per acre, almost nothing is known of the chemical nature of this material.

The difficulties, then, in attempting to isolate harmful organic compounds from infertile soils are due to ignorance of what compounds are harmful to plants and what are not, and also to lack of knowledge of the chemical nature of the organic matter of the soil and consequent lack of methods for dealing with such material.

The first crystalline organic compound isolated from a soil was a nitrogenous body, picoline carboxylic acid, which was obtained by a process which had its starting point in a solution of a portion of the organic matter in sodium hydrate solution. This body is a definite crystalline compound with very faint acid properties and has also the power of acting as a base toward strong acids. Along with the isolation of this compound there were obtained indications of the presence in the same soil of other bodies, some of which are related to it.

From the same and another soil by a modification of the same method another organic compound was obtained. This compound, dihydroxystearic acid, is non-nitrogenous and is in no way related to the nitrogenous body first isolated. Dihydroxystearic acid, like picoline carboxylic acid, is a well-defined crystalline chemical compound heretofore known only as a laboratory product.

The properties of these two organic compounds were tested by the effect of their solutions on wheat seedlings. Picoline carboxylic acid was found to be harmful in concentrations of 100 parts per million, and like many poisons had a stimulating effect when present in small quantities. Dihydroxystearic acid was injurious in all concentrations tested and ultimately caused death of the plants in concentrations of 100 parts per million.

Two other crystalline organic compounds previously undescribed in the literature were isolated from a soil. One of these, which has been named agroceric acid, is a member of the waxy acids; the other, which has been named agrosterol, belongs to the cholesterol group of bodies. Neither of these substances appears to be harmful to wheat and are of interest in the study of soil fertility chiefly with regard to their possible connection with the generation or destruction of injurious or beneficial compounds, although it is not impossible that they may be themselves harmful to plants other than that tested.

Apart from the purely scientific interest attached to the isolation from soil of any definite organic compound, the work here stated furnishes a simple tangible proof of the presence of injurious organic compounds in soils and should lay the foundation of the rational study and remedy of unfavorable conditions in such unproductive or so-called "exhausted" soils.

In the present bulletin there are described four organic compounds isolated from soils, all well-defined crystalline bodies, one of which is quite injurious, one slightly harmful but related to much more harmful compounds, and two that are not harmful so far as the wheat seedlings used in the tests are concerned, although, as pointed out above, other plants may be quite differently affected by these substances.

In addition to these, there have been isolated a number of other well-defined bodies, likewise crystalline. These various soil compounds are being studied and as far as possible their nature and properties will be determined and the results given in future publications.

THE DEATH OF PROF. CANNIZARRO.

PROF. CANNIZARRO, the well-known Italian chemist, recently died at Rome, at the age of 84. In the history of chemical philosophy his name will be remembered for the part he took in placing the atomic theory on a firm and secure basis.

He was born at Palermo in 1826, and educated at the Normal School and University of his native place. Having devoted himself to the study of physiological chemistry he was, in 1845, appointed assistant to Rafaelle Piria, then Professor of Chemistry at Pisa. Two years later he returned to Sicily and took part in the revolutionary outbreak in 1848. He served as an officer of artillery with the insurgents, and on their defeat he fled to France, finally making his way to Paris. Here he obtained a bench in Chevreul's laboratory ,and working with F. S. Cloëz, discovered the compound cyanamide, in 1851. In this year he was appointed Professor of Physical Chemistry at the National College of Alessandria, in Piedmont, and during his tenure of this office he prepared benzyl alcohol by treating oil of bitter almonds with alcoholic potash—a reaction now known by his name. In 1855 he became Professor of Chemistry at Genoa, and in 1861 he went to Palermo in the same capacity. In 1871 he was appointed Professor of Chemistry and Director of the Chemical Institute at Rome, while at the same time, in view of his scientific distinction, he was elected to the Senate, of which he became Vice-President.

In the middle of last century there was great uncertainty as to the criteria for determining the atomic weights of the elements, and this was reflected in the confusion which surrounded the formulæ used by different chemists to express the composition of compounds. In his "Sunto di un Corso di Filosofia Chimica," which was published in 1858, and ranks as one of the classics of chemical literature, Cannizarro pointed out that the incongruities disappeared and order was introduced if the distinction between atoms and molecules were properly observed, and he showed how it was possible to ascertain the atomic weights and their relations to the molecular weights by the aid of the specific heats of the elements, and of the hypothesis put forward by his countryman, Avogadro, nearly half a century before, that under equal conditions of temperature and pressure, gases contain equal numbers of molecules. This achievement won for him, in 1891, the Copley Medal of the Royal Society, of which he was chosen a foreign member in 1889; and a still earlier English recognition of the value of his work, was his selection, in 1862, as a foreign member of the Chemical Society, before which, ten years later, he delivered the Faraday lecture,

SOURED MILK.

ITS NATURE, PREPARATION, AND USES.

BY R. T. HEWLETT.

THERE seems to be little doubt that as age advances the microbial flora of the human intestine, especially of the lower portion or large intestine, often undergoes a change both in the number and in the character of the micro-organisms present. From middle life onward the number of microbes increases, and species capable of inducing putrefactive decomposition of proteins become more abundant. This change can be roughly gaged by making microscopical preparations of the dejecta and staining by the Gram process, a selective method by which certain organisms only are stained. In the child's dejecta Gram-staining microbes are relatively scanty and are mostly *Bacillus bifidus* and *B. acidophilus*, and it is noteworthy that these are lactic-acid producing bacilli. In and after middle life Gram-staining forms usually become more and more numerous, the Gram-staining species now being principally *Bacillus putrificus* and *B. Welchii*, bacteria which induce marked putrefactive decomposition of proteins.[1] In unhealthy conditions of the intestinal tract somewhat similar changes or various abnormal fermentations may occur.

Metchnikoff[2] in a study of the nature of senility formulated the hypothesis that it is caused, partially at least, by auto-intoxication, poisoning by the absorption of products derived from the action of micro-organisms in the digestive tract. Such poisons would be the products of the putrefactive decompositions brought about by the micro-organisms named, and also bodies belonging to the phenol series which are formed by the action of *Bacillus coli*, which is always present in the intestines, becomes more and more numerous from youth to old age, and which also multiplies excessively in unhealthy conditions of the digestive tract. In seeking for some agent which would combat the multiplication of micro-organisms in the intestine, particularly these harmful forms, Metchnikoff conceived that lactic acid, which has no deleterious action in the human economy, would probably effect the end desired, since the growth of these bacteria is inhibited by a moderate percentage of this acid. Bienstock, for example, found that the *B. putrificus* is inhibited in growth by *B. coli* thanks to its acid-producing power, the acid formed, though small in amount, being lactic acid. Simply to introduce the acid as such would, however, be of little use, for it would be absorbed and decomposed long before it reached the large intestine. Metchnikoff therefore sought for some means whereby lactic acid might be formed *in situ*, and naturally fell back on the use of lactic-acid-producing bacteria, which, if they could be established in the large intestine, might there produce sufficient lactic acid to inhibit the growth of putrefactive and other deleterious forms. But the problem was not an easy one, for it entailed the finding of a lactic acid ferment which would grow at body temperature (99 deg. F.) and maintain itself in spite of the competition of the other micro-organisms present. The ordinary lactic acid ferments found in milk grow best at 75 to 85 deg. F., and are unsuitable.

Metchnikoff says,[3] "I had no illusion as to the difficulty sure to be encountered in any effort to introduce lactic microbes into the intestinal flora which has been preoccupied by a multitude of other microbes. To make surer of the result, I chose the lactic microbe which is the strongest as an acid producer. It is found in the *Yoghurt*, which originates in Bulgaria. The same bacillus has also been isolated from the *leben* of Egypt; and it is now proved that it is found in the curdled milk of the whole Balkan peninsula, and even in the Don region of Russia." Metchnikoff also noted that some of those who consumed a diet of little else than the soured milk lived to an advanced age. This then was the origin of the use of Bulgarian sour milk, and of the introduction of artificial substitutes for the natural article. It may be added that the use of sour milk seems to be widespread in the East, for it is found also in Turkey, Siberia, and Asia Minor, and in India under the name of "Dadhi."[4] As Chaterjee says, "The extensive use of one or other varieties of fermented milk, produced by means of a special ferment in Eastern countries, probably owes its origin to the difficulty of preserving milk in a sweet condition for a long time, in comparison to cold countries; milk when undergoing spontaneous decomposition in hot climates becomes changed within a few hours to a foul-smelling fluid in which the casein and the fat have undergone liquefaction, whereas, when fermented by means of the special ferment, the decomposing, gas-producing, proteolytic bacilli are killed off by the more vigorous organism of the ferment, which has no destructive action on the fatty or albuminous constituents of milk, so that by this means milk can be kept in a condition fit for consumption for a long time."

The bacteriology of the various natural sour milks is somewhat complex and not yet fully elucidated, although considerable research has been devoted to it. Micro-organisms of a peculiar type are present in all. One of the first to be isolated was the *Bacillus bulgaricus*, a large Gram-staining, non-sporing, rod-shaped organism, which grows best at temperatures between 110 deg. F. and 120 deg. F. Development, however, is slow even at the optimum temperature, taking three days for the maximum production of lactic acid in milk, and it is therefore unsuited for the preparation of artificial soured milk. Another organism is the "granule bacillus" (Körnchenbacillus) of Kuntze. This is probably the organism so often spoken of as the "bacillus of Massol," and is widely used for the preparation of soured milk, as it grows rapidly and well at a temperature of about 100 deg. F. and produces a relatively high percentage of lactic acid. The name of "granule bacillus" is derived from the fact that granules which stain deeply are present in the bacterial cell. In all the natural soured milks somewhat similar micro-organisms are to be found. It is of interest that Kuntze has suggested that these Bulgarian lactic ferments are allied to the *B. acidophilus* and *B. bifidus*, which, as already stated, are present in the child's intestine, and they are probably primarily of intestinal origin.

In natural sour milks the special lactic acid ferments are always associated with other ordinary lactic acid bacteria, particularly a Streptococcus (*S. lacticus*), and a mixed culture of this last-named organism with the bacillus of Massol presents advantages over the use of the latter alone.[5] For instance, when the *B. bulgaricus* grows alone in milk it has some effect on the fat, producing small quantities of nauseous tasting substances, but Metchnikoff has shown that this result is entirely obviated by a symbiotic growth with an ordinary lactic acid organism. The ingestion of milk soured by an ordinary lactic acid organism also tends to produce in the intestine an acid environment which favors the growth and persistence of the special lactic ferment, the bacillus of Massol.

Various procedures are adopted for the preparation of the natural sour milks. According to one account, Yoghurt is prepared by boiling milk until it has diminished to half its volume by evaporation; it is then allowed to cool somewhat and a little of a previously prepared sour milk is added and the whole allowed to stand in a warm place until next day. Another method is to wipe round a wooden bowl with a piece of cheese (presumably prepared with the sour milk) and then to introduce into the bowl the boiled milk. Dadhi is prepared by boiling milk for some time, cooling to blood-heat, and then inoculating with a needle dipped in a former brew. The inoculated milk is covered with a blanket and kept in a warm place for 12 hours.

For the artificial production of soured milks the milk is well boiled in order to sterilize it and destroy undesirable organisms, and when it has cooled sufficiently a "starter" consisting of a pure culture of the proper lactic ferments is added. The inoculated milk is then kept at 100 deg. F. or thereabout for from 10 to 24 hours, according to the amount of starter added, and should then be fit for use. Many starters, both liquid and solid (tablets), are to be had, but only a few are to be recommended, as some are grossly contaminated with undesirable bacteria. Another method is to add a little of the previous day's preparation to the milk to be soured. Some of the large dairy companies also supply the soured milk ready for consumption.

Considerable care must be exercised in preparation to use sterilized vessels and to safeguard the milk from contamination during incubation. The milk properly prepared should be thoroughly curdled, possess a not unpleasant tart flavor, and have a marked acid reaction. Some of the older starters contained sporing bacilli which though they curdled the milk (owing to tryptic ferments) gave rise to little or no acidity. Preparations containing a combination of the bacillus of Massol with *Streptococcus lacticus* or *lebenis* are probably the most suitable.

The internal administration of tablets, etc., containing the lactic ferments, in place of the soured milk, is of questionable utility.

Although some are still skeptical as to the value of soured milk, it can hardly be doubted that it is beneficial in many complaints.[6] Among these are (*a*) those depending on abnormal putrefaction of proteins in the intestinal tract, and including certain cases of acute enteritis and acute and chronic colitis; (*b*) auto-intoxication, with products of intestinal putrefaction, as in many cases of general failure of health in elderly persons, forms of anæmia, neurasthenia, with flatulent dyspepsia, etc.; in minor ailments such as lassitude, headache, some forms of constipation and diarrhœa, rheumatic pains, and the like, benefit frequently results. It must also be recognized that even if the soured milk as such does little good, it often enables an addition of valuable and easily assimilable food-stuff to be made to the diet by its use. On the other hand, soured milk is by no means a universal remedy, and should not be taken indiscriminately without medical advice, as it sometimes disagrees.

Moreover, the home preparation of soured milk cannot be recommended unless it is undertaken by a member of the household having some knowledge of the scientific principles involved in the practice of sterilization and use of pure cultures.—Nature.

[1] Herter, "Bacterial Infections of the Digestive Tract," 19 7.
[2] "On the Prolongation of Human Life."
[3] Century Magazine, November 1909, p. 56.
[4] Chaterjee, Ind. Med. Gazette, September, 1909, p. 329.
[5] "On the Bacteriology of Yoghurt," etc., see Luerssen and Kühn, Centralbl. f. Bakt., Abt. ii. xx., 1908, p 234; Kuntze, ib., xxi., 1908, p. 737; White and Avery, ib., xxv, 1909, p. 161; Hastings and Hammer, ib., xxv., 1909, p. 419. Full references to the literature of the subject are given in these papers.
[6] Herschel, Proc. Roy. Soc. Med., January, 1910.

THE NUMBER OF ANIMAL SPECIES.

THE well-known zoologist A. E. Shipley, in a paper read before the British Association for the Advancement of Science, gives interesting statistics concerning the numbers of known species of animals of all classes. About ten years ago Guenther made a careful comparison of the numbers of species of the various groups of animals that were known in 1830, or thereabout, with the numbers known in 1881. During the intervening half century the known species of mammals increased in number from 1,200 to 2,300, birds from 3,600 to 11,000, reptiles from 543 to 3,400, fishes from 3,500 to 11,000, mollusks from 11,000 to 33,000, moss animalcules from 40 to 120, crustacea from 1,290 to 7,500, archnida (spiders, etc.) from 1,048 to 8,070, myriapods (centipedes, etc.) from 450 to 1,300, insects from 49,100 to 220,150, echinodermata (sea urchins, starfishes, etc.) from 230 to 18,043, worms from 372 to 6,070, cœlenterata from 500 to 2,200, foraminifera from 50 to 400, and protozoa from 305 to 3,500. The total number of animal species of all kinds known in 1840 was 73,588; in 1881 the number had increased to 311,653. The average number of new species discovered each year since 1881 may fairly be estimated at about 12,000, so that the total number of species now known must exceed 600,000. But the number of species yet unknown is probably very much greater than this. In 1895 Sharpe estimated the number of known species of insects at a quarter of a million, and expressed the conviction that ten times as many insect species yet awaited discovery. Insects and small animals in general offer an almost unlimited field for exploration, while in the case of large animals, and especially of mammals, it is probable that a majority of living species is already known.

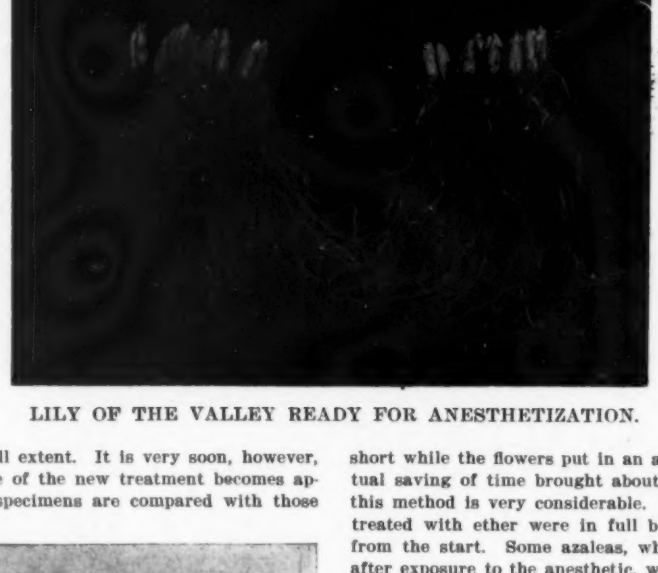
In a paper read some little time ago before the American Institute of Electrical Engineers, Mr. P. M. Lincoln elaborated a hydraulic analogy to a three-phase line which will be useful in enabling electrical engineers to form a conception of the phenomena of electric surges. He concludes that electrical transmission lines can be guarded against the dangers arising from electrical surges by using some or all of the following precautions: By means of an overhead guard wire the quantity of electricity which a given lightning discharge is capable of superposing upon a transmission line is kept down. In practice it has proved of value in many cases of high-tension transmission. The use of efficient lightning protectors is absolutely essential. By earthing the neutral solidly the potential of the line is prevented from attaining dangerous values. It is also very essential to insulate the windings of electrical apparatus so that they can withstand a momentary potential many times greater than the normal.

THE USE OF ANESTHETICS FOR PLANTS.*

ARTIFICIAL ACCELERATION OF GROWTH.

BY S. LEONARD BASTIN.

NOWADAYS the gardener has to adopt all kinds of ingenious devices in order to obtain the flowers for which there is such an unceasing demand. One of the most interesting of those methods which have been recently introduced is the system of the anesthetization of plants, in order that they may come the more quickly to perfection. Some years ago, Dr. Johannsen, of Copenhagen, carried out a number of elaborate inquiries in order to find out the effect of chloroform and ether upon vegetable tissue. After a long series of experiments he was able to show that certain plants, when submitted to the influence of the vapors of these drugs while in a dormant condition, behaved in a curious way afterward. It seemed that the anesthetic intensified their restfulness, and brought about a remarkable activity when ordinary growth was allowed to be resumed. Moreover, it was noted that the all-round excellence of the plants so treated was greater than in the case of specimens which were in a normal condition.



LILY OF THE VALLEY READY FOR ANESTHETIZATION.

It soon became evident that a discovery of real commercial value had been brought to light. The production of flowers is such a serious business nowadays that anything which will save the grower time is a matter of great importance. Further experiments went a long way to indicate the lines on which the treatment would be likely to be most successful. It was found that lilacs, azaleas and especially lilies of the valley were plants which were amenable to the ordeal. As well, many sorts of bulbous species seem to repay for the trouble by an accelerated growth and an enhanced beauty of development. Of course the expense involved in the system is so trivial as scarcely to be taken into consideration.

YOUNG, WELL-BUDDED LILAC WITH ROOTS WRAPPED READY FOR ANESTHETIZATION.

AIRTIGHT BOX FOR ANESTHETIZATION OF PLANTS.

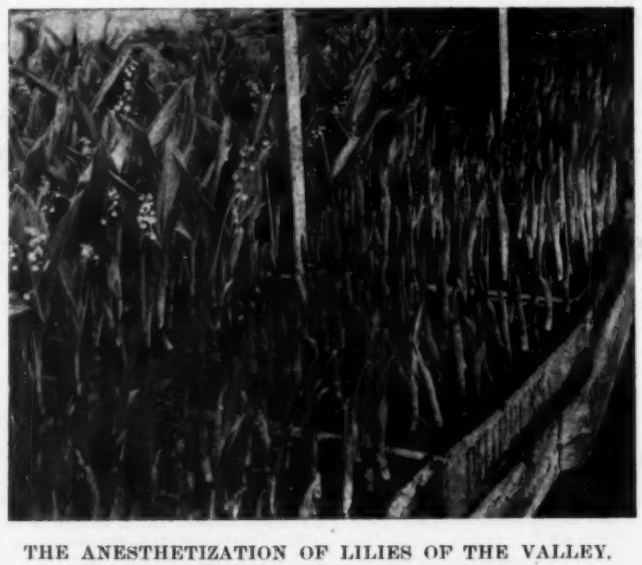
The chloroform or ether is placed in the receptacle at the top and the heavy vapor sinks to the bottom

The mode of procedure is on the following lines When the plants or roots are in a perfectly restful condition they are taken in hand for treatment. A perfectly airtight box or tin case is obtained, and all the specimens are stored away in the bottom of the receptacle. From the inside of the lid of the case is suspended a smaller vessel, and it is into this that the spirit is poured. It is necessary that the temperature throughout the proceedings should not fall below 62 deg. F. As soon as the chloroform or ether is placed in the vessel the lid of the case must be closed down and is not again to be opened. Of course, the vapor from the drug being heavier than air sinks to the bottom of the box and mingles among the roots and plants lying there. For a period of forty-eight hours the case is left, at the end of which time all the specimens are removed, planted and grown in the ordinary manner. No very great degree of heat appears to be desirable beyond that available in a well-warmed glasshouse.

At first the anesthetized plants are only exposed to the light to a small extent. It is very soon, however, that the advantage of the new treatment becomes apparent when the specimens are compared with those which have been grown normally. A few days elapse, and the plants seem literally to jump into life; the buds burst open, the leaves begin to expand, and in a short while the flowers put in an appearance. The actual saving of time brought about by the adoption of this method is very considerable. Lilies of the valley treated with ether were in full bloom in a fortnight from the start. Some azaleas, which were potted up after exposure to the anesthetic, were out on March 8, although they had only been growing from the 25th of February. Specimens which had not been treated at all, and were started at the time of the others, did not come to maturity until at least a fortnight later. In the case of lilac and other plants the saving of time was equally remarkable and satisfactory.

The different species appear to succeed best under a special anesthetic, and it is a matter of no little trouble to find out the better drug to use. Thus it is found that ether seems to be better suited to the requirements of lilac and chloroform in the case of azalea. Any amateur enough interested to take the matter up will find a most promising field for investigation in this question of the plant and the anesthetic. The expenses involved are, of course, very small when the matter of outfit is considered. A certain amount of care in the handling of the chloroform and ether is necessary, as it should be remembered that these are volatile and highly inflammable spirits.

In France the treating of lilac with anesthetics at the present time has developed into a large industry. The new method has entirely overcome a difficulty which has always troubled the forcer of this plant in the early months of the year—that is, the matter of leafage. Lilac could be induced to develop its blooms with heat, but the plants would not develop their foliage. After the specimens have been anesthetized the leaves are produced in the greatest profusion at the same time as the flowers. A similar result is to be noticed to a large extent in the case of lilies of the valley. On the whole this method offers many interesting opportunities of study that may be turned to account.



THE ANESTHETIZATION OF LILIES OF THE VALLEY.

Note difference between plants in foreground and those at back.

* From American Homes and Gardens. Published by Munn & Co., Inc.

SQUIBS, FUSES, AND DETONATORS.*

HINTS FOR THE MINER.

BY C. E. MUNROE AND CLARENCE HALL.

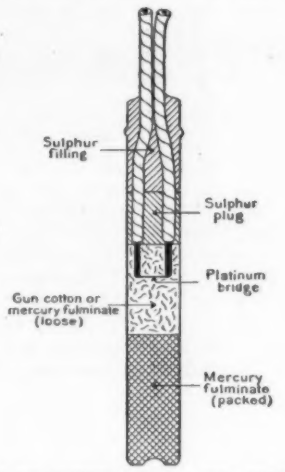
AN explosive is a compound which can be caused to explode by various means. All explosives can, under some circumstances, be made to explode by fire. Some of them can be caused to undergo a detonating explosion by setting off a detonator in contact with them. In blasting use is made of both these means for setting off explosives, the means used being determined by circumstances.

In setting off by means of fire, use is made of miner's squibs, or of fuse. Miner's squibs consist of tapering paper tubes about 7 inches long, filled with fine gunpowder, one end of each paper tube being treated with chemicals so as to form a slow-burning match, which, when ignited, burns so slowly as to give the miner time to reach a place of safety before the explosion. When used the squib is placed in the needle hole, or blasting barrel, through the tamping, with the match end of the squib outward. When the match is ignited the fire burns slowly along the tube until it reaches the powder core. Then the squib darts forward like a rocket, leaving a trail of flame behind which spurts out from the needle hole, and the fire continues burning along the powder core of the squib until it bursts out of the other end of the tube and so ignites the charge.

In experiments made at the Pittsburg testing station it has been found that, though the burning match on the end of the tube of the squib does not inflame a mixture of mine gas and air, as soon as the powder core is ignited the flame that then flashes out from the end of the squib will explode the mixture. Hence squibs should not be used in any gaseous mine.

Fuse, as used in coal mines, is sent out into the market in coils 50 feet long, and in several varieties, but all consist of a core of mealed gunpowder inclosed in two or more layers of yarn and generally surrounded by tape that has been dipped in a waterproofing composition. Some varieties are then dusted with substances like powdered soapstone, to prevent the sticky surfaces from sticking to one another. The kinds of fuse most used are hemp fuse, cotton fuse, single-tape fuse, double-tape fuse, triple-tape fuse.

When one end of a fuse of any variety is lighted the powder core burns slowly along the fuse till at last the flame rushes out at the farther end and, if it touches a charge of powder, sets it off. Like squibs, fuse throws off flames when lighted, and hence the use of fuse in a gaseous mine cannot be recommended. Fuse should be so made and should be in such a condition when used that any part of any coil will burn at the rate of a foot in eighteen to twenty seconds. This is of the greatest importance, because in setting a charge the blaster or shot firer cuts a piece of fuse to reach from the charge to the opening and long enough to give him ample time, after the end has been set on fire, to reach a place of safety before the flame fires the charge. Therefore, careful tests should be made of the rate of burning of pieces of the fuse whenever there is any doubt whatever as to its soundness. Although the manufacturers may produce a fuse with a regular rate of burning, the rate may be changed by bad handling, as, for instance, by squeezing the fuse so as to disturb the powder core, or by suddenly and roughly opening the coil when it is stiff from cold, so as to crack the fuse; or the fuse may be injured by rubbing against the rough surfaces of the rock. In cutting the fuse and in fitting it into place, care must be taken that the powder core does not run out from the fuse, for that might cause a misfire.



ELECTRIC DETONATOR, SHOWING ITS COMPONENT PARTS.

Detonators (which are also called blasting caps, and sometimes are called exploders, though the last term applies to any means of producing an explosion, and therefore is not commended here) consist of copper capsules about as thick as an ordinary lead pencil, which are commonly charged with dry mercury fulminate or with a mixture of dry mercury fulminate and potassium chlorate that is compressed in the bottom of the capsule, filling it to about one-third of its length.

Dynamite and other detonating explosives are in practice fired by means of detonators, for though they may be exploded by the aid of squibs or fuse, or by means of gunpowder primers, yet the explosion so produced is not a complete one; the explosives are not used to their best advantage; all of the work that they can do is not done; and, moreover, the gases that are produced are usually dangerous. Where high explosives are employed, it is safer to fire with detonators strong enough to cause their most complete explosion. Permissible explosives should be fired by detonators, and are best fired by electric detonators of the strength prescribed for each one.

Detonators are fired by the aid of a piece of fuse. The end of the fuse is inserted in the mouth of the blasting cap and carefully pushed down until it gently touches the surface of the detonating composition, and then the cap is crimped onto the fuse. The cap, with the attached fuse, is inserted in the charge to be fired, which, when placed in the bore hole and tamped, is ready for firing. The end of the fuse is lighted, and the fire burns down the powder core until it streams against the detonating composition, which then detonates and causes the detonation of the explosive with which it is in contact.

It has been found at the Pittsburg testing station that the flame which rushes out from a fuse when it is ignited at the mouth of a bore hole will ignite an explosive mixture of mine gas and air. Therefore fuse should not be used, either alone or with detonators, in fiery mines.

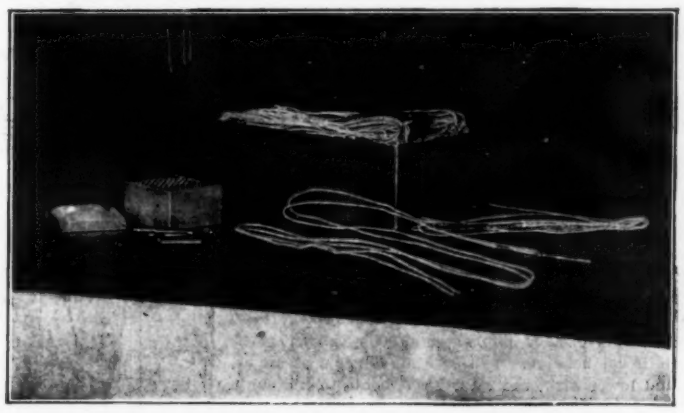
The practice of fitting the fuse to the detonator is common in quarries, tunnels, and mines that are not gaseous. Accordingly, it is customary to make both detonators and fuses in standard sizes, so that the fuse may easily slip down within the mouth of the detonator and yet make a neat fit within it.

By the use of electric detonators (also called electric fuses), the dangers that are common in the use of squibs or fuse in gaseous coal mines are avoided. These electric detonators are simply ordinary detonators that have been fitted with a means of firing them by the electric current. This is done by inserting within them two copper wires, joined at the inner

MINER'S SQUIB.

MINER'S SQUIB AND FUSE.

CRIMPING DETONATOR ON FUSE.



DETONATORS AND ELECTRIC DETONATORS.

* Abstracted from Bulletin 423 of United States Geological Survey.

ends by an extremely fine platinum or other high-resistance wire, which, like the carbon filament in the ordinary incandescent lamp, becomes heated till it glows when an electric current is passed through it. This wire, known as the bridge, is placed above the detonating composition, and is surrounded by gun cotton or loose fulminate. The space above it and the mouth of the capsule are then filled and closed by means of a plug of sulphur or other waterproof composition, which is poured in while soft. The copper wires pass through the plug and are long enough to extend outside the capsule. These outer ends are called the legs or wires of the electric detonator. Although the copper wires are bare within the electric detonator, the legs outside are covered with an insulating wrapping. These legs are made of different lengths in order to suit different depths of bore holes. The charge of detonating composition differs in the different grades of electric detonators so as to give different strengths.

In loading bore holes electric detonators are placed in the charge just as detonators with fuse are, and the bore holes are tamped in a similar manner. To fire the charge, the legs of the detonator are connected by leading wires to an electric device at a safe distance, and from it the current is sent to fire the blast. No flame can escape from the bore hole during the firing, for the tamping fills the hole completely, and hence blasting in gaseous mines is made much safer.

Only electric detonators are used at the Pittsburg testing station in the tests of explosives for use in mines.

What are called delay-action electric "exploders" or detonators are now being offered for use where a number of holes are to be fired at once, but so that the charges may explode one after another. This is done by placing a piece of fuse or other device in the electric detonator between the detonating composition and the bridge and inclosing the whole so that the flame may not escape from the blast hole. In the present state of knowledge this practice is not commended for use in coal mines.

Never attempt to pick out any of the composition. Do not drop them or strike them violently against any hard body. Do not lay them on the ground where they may be stepped on. Do not step on them. In crimping, take the greatest care not to squeeze the composition, and never crimp with the teeth, for there is enough composition in one of these small capsules to blow a man's head open. They should be stored in a dry place and in a building apart from any other explosives. They should never be carried into a mine with other explosives, and they should never be placed in a mine near other explosives except in bore holes. When carried or shipped they should be packed firmly with a quantity of elastic material, such as felt or the coiled legs of the electric detonators, about them, and they should not be exposed to heat, blows, or shocks of any kind.

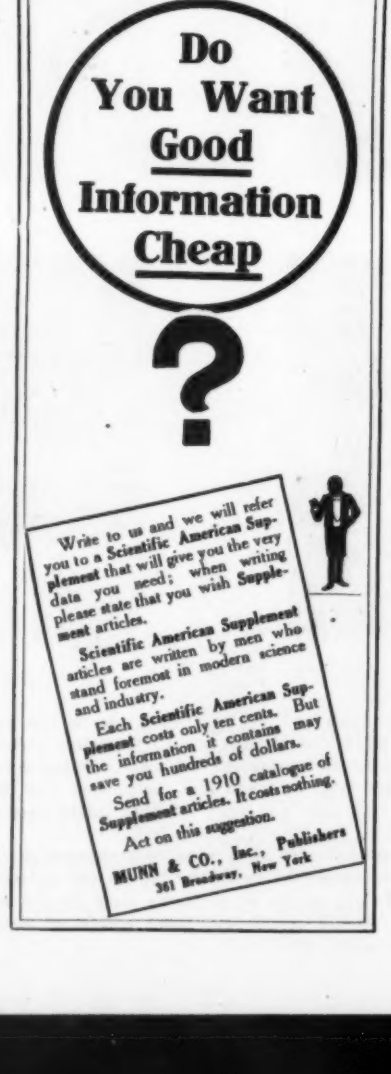
In a recent number of Power, Mr. H. B. Taylor gives a detailed description of four 18,000-horse-power reaction turbines, of the vertical-shaft, single-runner, inward-flow, Francis type, operated under a 525-foot head at 400 R. P. M., with an efficiency of 89 per cent. The turbines are for the Great Western Power Company's station on the Feather River, Oroville, California. It is only within the last few years that the reaction type of turbine has been used for heads of over 300 feet, the impulse or Pelton wheel having hitherto been used almost exclusively for such heads. The turbines and governing apparatus were made by the I. P. Morris Co., of Philadelphia. The runner, of special bronze, runs in a cast-steel volute casing, and the water is delivered to the runner through cast-steel movable guide-vanes spaced round the periphery of the runner. The governor, situated near the alternator, controls the guide-vanes by oil pressure, and the piping is made large so that the inerta of the oil may be overcome in a very small increment of time. The whole operating mechanism is so sensitive that the guide-vanes begin to move before the speed of the turbine has varied more than ½ per cent from the normal. The normal pressure of the water in the wheel casing is 220 pounds per square inch, and the steel casing was tested to 400 pounds. The weight of the runner vertical shaft and the rotating field system of the 10,000-kilowatt alternator is 145,000 pounds, and this is carried by an oil-thrust bearing. The bearing consists of an upper and lower disk, the former connected to the shaft. Between the disks there is an annular chamber into which oil is pumped at a pressure of 250 pounds per square inch. The oil is cooled by water piping. In the efficiency tests, the volume of the water delivered to each turbine under various conditions of load was determined by taking traverses with Pitot tubes, in the penstock. The Pitot tubes were carefully calibrated by checking against a weir at Niagara Falls. The pressure head was determined by taking the average of the readings of eight piezometer tubes connected to eight equi-distant points on the circumference of the penstock. The efficiencies under a 420-foot head and 14,000 horse-power were as follows: No. 1, 87 per cent at 87 per cent load; No. 2, 87 per cent at 90 per cent load; No. 3, 88.2 per cent at 93 per cent load; No. 4, 89 per cent at 91.5 per cent load.

SCIENCE NOTES.

Applied science has already made some contributions to American education and civilization, and so far as its use in the schoolroom is concerned, applied science, as an educative agency, is not exceeded in value by any other instrumentality. Its very general acceptance by teachers and students in our leading educational institutions does not prove its value, but does prove that its value is being appreciated.

A new lecture experiment on the pressure of light has been devised by A. Amerio. He uses a cylinder about 3 centimeters in diameter and 1 centimeter high, made from a sheet of thin Al blackened with Indian ink and covered with a thin layer of transparent varnish; the silk fiber by which the cylinder is suspended lies in the prolongation of the axis. The support of the absorbent material, being a good conductor of heat, causes a diminution of the radiometric effect owing to the small difference of temperature between its two faces; the distribution of the energy of the incident beam may be asymmetric without causing inconvenience, since all the radiometric actions converge toward the center, and lastly the thin layer of varnish removes the objection that the radiometric effect destroys the light pressure effect.

On his second invasion of Britain in B. C. 53, Julius Cæsar sailed up Southampton Water, and after a sturdy resistance by the Britons took and destroyed Trisanton, but, beyond that, Cæsar seemed to have done little by his second invasion, save to extract at the point of the sword a promise from the Britons to recognize the power of Rome by an annual payment, and upon this he withdrew. To avoid a repetition of this attack the Britons re-established their capital twelve miles farther up the river Itchen, near the ancient oppidum known as Cær Gwent, now St. Catherine's Hill. Here, in the valley of the Itchen, they built their new capital, which they called Camelot, and erected a royal palace, where stand the ruins of Wallesey, or Wolvesley, Palace at Winchester. To protect the mouth of the Itchen they constructed a great defensive work at Wooiston, considerable traces of which are still quite evident, and where within the last few years remarkable discoveries of bronze implements and Celtic coins have been made. This camp was referred to in the account of the invasion of Aulus Plautius in the year 43 A. D. as Cær Peris, or Byris, or Bere, which was corrupted to-day into Pear Tree Green. The Roman station of Clausentum later became the seat of the Roman power in this district, and it remained a city till the end of the Saxon period. Winchester continued to be the Celtic capital till the more thorough and effective invasion of Vespasian took place, which broke up the Celtic form of government and established that of Rome.—The Architect and Contract Reporter.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TRADE NOTES AND FORMULÆ.

Volatile Copal Varnish.—*a*. Copal, 60 parts; ether, 10 parts; alcohol, 60 parts; oil of turpentine, 40 parts. *b*. Copal, 10 parts; acetone, 30 parts; alcohol, 30 parts. Distill at 133 deg. F., whereby the acetone, which proves very serviceable as a solvent of the copal, will be nearly all recovered, the copal remaining in solution in the alcohol.

A Dull Copper Bronze (J. Rhein).—Rub umber, graphite, and a quantity of copper bronze to a brown paint with siccative, and coat the object with it completely, using a fine bristle brush. Shade the raised portions immediately with copper bronze, and glaze, when dry, with spirit lacquer. The bronze will be somewhat lighter in tone if it is dried after the first coat of brown, then coated with copal lacquer, containing little oil, and bronzed, dried and glazed as previously directed. In rubbing up the brown color, it is well to add a few drops of turpentine oil from time to time, as the siccative dries very rapidly.

Fine Copper Bronze (J. Rhein).—Coat the object with copal lacquer and bronze with a mixture of a quantity of copper bronze with some graphite and umber. When dry, coat with dilute brown spirit lacquer, touch the raised portions with a copal lacquer containing but little oil, using a bristle brush, then bronze again with copper bronze. The bronze dust which falls into the hollows and crevices must be removed with a clean hair brush, and the purpose of the spirit lacquer is to make this possible. Finally, glaze with brown or reddish brown spirit lacquer. All bronzings, unless directions are given to the contrary, should be allowed to dry slowly:

Colored Copying Pencils.—Red: Dissolve 65 parts of ponceau red in 200 parts of shellac soap solution by heating and add 2 parts powdered tragacanth, 4 parts of albumine dissolved in 12 parts of water. Stir into this colored paste, 130 parts of cinnabar (vermilion) mass and, constantly stirring, evaporate it in a water bath, at a temperature of 50 deg. R. (144 deg. F.) until it is of such consistency as to be capable of being pressed into sticks. (Shellac soap solution is made as follows: 6 parts rosin soap is dissolved in 60 parts of water, and in this 4 parts of shellac dissolved by boiling. Rosin soap is obtained by saponification of 20 parts of rosin and 80 parts of palm oil, with caustic soda. Cinnabar mass: equal parts of the finest cinnabar and kaolin mixed, ground, dried and pulverized.) Blue: 20 parts of the finest aniline blue, soluble in water, dissolved in 40 parts of water and boiled, then add to the recooled solution, 1 part of powdered tragacanth with 4 parts of milori blue mass, in finest powder, stirred in; the pressed sticks must be exposed several days to the moist air. The sulphate of soda that effloresces must be removed by brushing off and rubbing off with damp cloths, which treatment should be repeated several times. The mass is then moistened with water in which 8 parts of sugar have been dissolved, then 4 parts of best albumine dissolved in 12 parts of water added and rubbed through a fine gauze sieve, next add to the mass ¼ part of indigo carmine and reduce it to the desired consistency in a water bath, at 156 deg. F. (Milori blue mass consists of: 1 part milori blue and 6 parts of the finest washed kaolin, both substances ground absolutely fine in a wet mill, dried and pulverized, adding before grinding 0.5 part of English sulphuric acid.) Black: 11 parts ponceau red, 15 parts aniline blue soluble in water and 1 part of pulverized tragacanth together with 1 part finest albumine, dissolved in 3 parts water, and then filtered, are dissolved in 60 parts of hot water and to the concentrated solution 30 parts of finely ground, fat clay, 8 parts indigo carmine and 3 parts of Chinese India ink added. The mass must be pressed several times and the sulphate of soda removed.

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